PLASTICS TECHNOLOGY

DECEMBER 1959

THE MAGAZINE OF APPLIED ENGINEERING

University Microfilms, Inc.,
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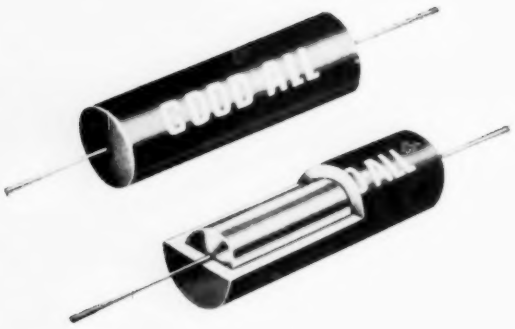
Ann Arbor, Mich.

59
F&E

Canadian General Electric Co., Ltd.

New streamlined transformers, molded in Epon resins, have superior insulation and dielectric strength. Accuracy and over-all performance are greatly improved.

Specify Epon® Resins...



Good-All Electric Manufacturing Co.

New Epon resin-molded 600 UE capacitors have superior moisture resistance. Offer rugged, trouble-free performance because Epon resin assures high dielectric strength, low leakage.

for potting, molding, sealing, encapsulating

SWITCH TO EPON resin-based compounds for potting, molding, sealing, and encapsulating to upgrade the performance of your electrical or electronic units . . . cut costs through design simplification.

Why? Because the excellent physical properties of Epon resins eliminate the need for conventional containers and housings. Size, weight, and complexity of components are reduced.

To lower costs and speed up production, manufacturers have moved in the direction of automation. In the new mixing, metering and dispensing equipment, even the most heavily filled Epon resin formulations can be used for high-volume, rapid-curing potting, encapsulating, and sealing operations.

Epon resins can be adapted to a wide variety of formulations designed to meet your specific needs. Write now for full information including a list of suppliers of Epon resin-based formulations and manufacturers of automatic mixing, metering, and dispensing equipment.

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Room Dividers molded of *Catalin* HIGH IMPACT STYRENE

The magical ease with which modern homes can be transformed through the use of versatile plastics is newly exemplified in these handsome screen panels by Beco*, whose plastic bird cages and flower planters are well-established consumer items. Do-it-yourself interior decorators can quickly assemble these molded filigree openwork panels of tough CATALIN High Impact STYRENE into single or multiple arrangements by attaching them to spring-action, floor-to-ceiling, rubbershod poles—and with an inexpensive touch of elegance divide large living areas without sacrificing a feeling of airy spaciousness.

Strong, rigid and light, CATALIN STYRENE . . . *the gem of plastics* . . . offers industry unlimited opportunities for product improvement at low cost. Besides a comprehensive range of styrene formulations—in general purpose, high impact, heat resistant, light stable and anti-static grades—Catalin supplies molders, blow molders and extruders with an unsurpassed spectrum of *styrene copolymers, polyethylenes, nylons* and the new *polypropylenes*. Inquiries invited.

*Molded and marketed by Bernard Edward Co., 5252 So. Kolmar Ave., Chicago 32, Ill.

Catalin Corporation of America Catalin **One Park Avenue, New York 16, N. Y.**

PLASTICS

THE MAGAZINE OF APPLIED ENGINEERING

TECHNOLOGY

December 1959, V. 5, No. 12

feature articles:

extrusion molding p. 37

by E. C. BERNHARDT

The important advantages inherent in screw plasticization make it certain that increased attention will be paid to extrusion-molding operations. Recent developments in extrusion molding machines are described and discussed for both domestic and foreign models. The final choice of optimum plasticating and molding device will depend on the requirements of the particular molding job.

stabilization of linear polyethylene against ultra-violet light p. 41

by G. A. CLARK and C. B. HAVENS

Linear polyethylene made by the Ziegler process has shown promise as a melt-spun fiber, but unstabilized monofilaments exhibit loss of physical properties, such as tensile strength, when exposed to ultra-violet light. Photo-oxidative degradation can be retarded by the use of appropriate antioxidants or efficient U-V light absorbers which affect separate phases of the oxidation mechanism. Results of tests show that combinations of antioxidants and U-V light absorbers provide effective stability to outdoor exposure.

evaluating plastics for compression molding of phonograph records p. 47

by W. E. COLEMAN

Experimental procedures and test results are given to show how a capillary extrusion rheometer can be used to evaluate and compare plastics materials, molding cycles, and molding conditions.

nondestructive quality-control tests on finished reinforced-plastic parts p. 51

by A. D. COGGESHALL

The theory and examples of practical usage are given for a quality-control procedure based on observing the creep or relaxation of parts heated slightly above the glass point while lightly stressed. The temperature-and-stress combination is highly specific for each application, and must be determined by actual experimentation. The test is nondestructive when the imposed stress is only a small fraction of the rupture strength and the imposed deformation of the part is found to be recoverable.

guest editorial:

publicity—an obligation or a sales aid! p. 45

engineering forum:

injection molding p. 62

by R. H. HOEHN

Mold finishes for polyolefins.

exploring fabrication techniques:

improved fabrication techniques . . . flexible polyurethane foam p. 58

by L. J. ZUKOR

feature stories:

better textile bobbins—faster and cheaper p. 50

reroofing with polyurethanes p. 57

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Opinions expressed by contributors do not necessarily reflect those of our editors

NBP BPA

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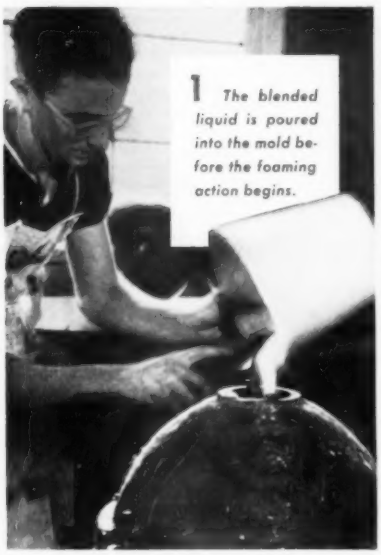
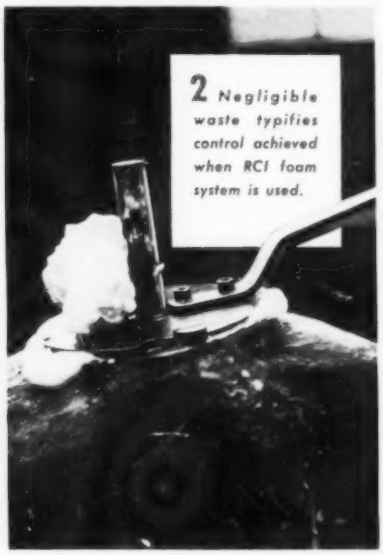
New York 17, N.Y.

"POLYLITE resins are indispensable to production of our unique foam buoy"

— says Lester Hegstad, Hanson Equipment Company





"**RCI POLYLITE** polyester resins have helped us obtain exactly the properties we want in our Skipperline Buoy," says Lester Hegstad, Vice President in Charge of Engineering, Hanson Equipment Company, Beloit, Wisconsin.

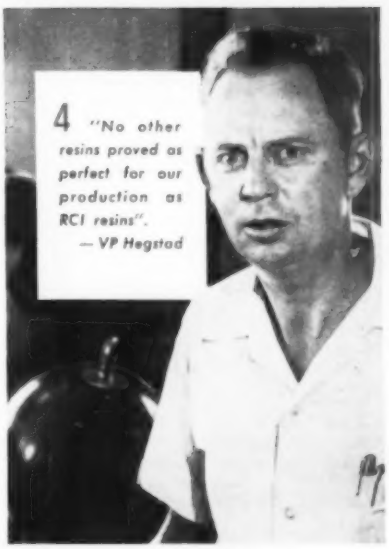
The buoys are constructed of polyurethane foam and a "skin" of reinforced plastic. The foam fills the body of the buoy and makes it lighter and more buoyant than wood or cork, as well as impervious to rot. The exterior is resistant to rot, unharmed by salt water, and won't chip, peel or require painting.

The foam core of the buoy is prepared by blending the POLYLITE ingredients and pouring them as a liquid into the mold which has been lined with the reinforced plastic "skin." Foaming and curing take place rapidly and at room temperature. The result is a hard, rigid foam with a high strength-to-density ratio and an exceptionally uniform structure of closed cells.

The "skin" is made from glass fiber cloth and two other POLYLITE resins — a colored gel coat and a bonding resin.

The Hanson Company also uses RCI resins in its manufacture of reinforced plastic tanks and boats. In every case the company has found that no other resins perform as well as the RCI line.

Perhaps there's a POLYLITE resin that can improve your products or production technique. Your REICHHOLD representative will be glad to discuss it with you.



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Letters to the Editors

Likes The Price Listings

Dear Sir:

A reduction in price for Pro-fax Polypropylene has occurred, as per the attached price list.

Since your magazine is referred to quite frequently, we feel the current price is important to the trade. We also realize the difficulty of keeping such a price list current, and congratulate you on the job that you are doing.

H. P. Grace, Manager
Cellulose Products Dept.
Hercules Powder Co., Inc.
Chicago 4, Illinois

• • •

Copies of Abstracted Articles

Dear Sir:

It would be appreciated if you would send us the article described on pg. 11 of your October issue, as follows:

"Extrusion of Dry, Plasticized PVC Powders," F. Freiman, *Ind. Plastiques Mod.*, Jan. 1959, describing the equipment as well as the process.

Irwin Cohn, Pres.
Great American Plastics Co.
Fitchburg, Mass.

(We print this letter only to remind our readers that copies of articles abstracted in our magazine should be requested from the publishers of the magazines where the articles first appeared.—Editor)

• • •

Others Make Mistakes, Too!

Dear Sir:

It recently came to our attention that due to an error, our book, "Epoxy Resins: Market Survey and Users' Reference," failed to include a bibliography of epoxy resin articles that have appeared in PLASTICS TECHNOLOGY.

This was very disturbing to us because we had felt we were presenting people with a complete epoxy bibliography and had unfortunately left out one of the most important publications in the field.

We wish to apologize to you and your readers for this error and to inform you that our second printing, just delivered, includes the complete PLASTICS TECHNOLOGY bibliography.

C. P. Waite, Dir.
Materials Research
Cambridge, Mass.

• • •

Information Wanted

Dear Sir:

I'm looking for a plastics manufacturer who can fabricate large quantities of small, saleable plastics items in the toy field. We are particularly interested in the process of vacuum forming.

L. L. Hyman, Pres.
Lawrence Drafting Service
Richmond, Va.

(Replies by our readers can be sent either directly to the inquirer or for transmittal by this office.—Editor)

• • •

Dyeing Polystyrene Tubing

Dear Sir:

We are trying to find a red dye for brush coating the interiors of short lengths of small diameter molded polystyrene tubing without crazing. Color should be deep red and as clear as possible.

C. J. Reimuller
Javex Mfrs.
Redlands, Calif.

(In his reply, Lee Zukor, our Engineering Editor, suggested two suppliers that could offer assistance.—Editor)

We invite letters from our readers for publication in these columns. Such letters may be of comment or criticism, requests for information, or of general interest. The only requirement is that all letters must be fully identified as to name of sender, company affiliation and address.

A letter will not be printed if publication is not desired by the sender, and the identity of the writer will be withheld, if desired.

—The Editor

PREVIEWS

of Next Month

The January 1960 issue will feature the following articles:

The Outlook for 1960. A series of special statement-predictions by spokesmen for selected plastics materials supplier companies on the industry's prospects.

•

Automatic Plunger Molding. J. A. Kempf, Head of Plastics Division, Bull Dog Electric Products Co. of Ohio, Div. of ITE Circuit Breaker Co., Urbana, Ohio.

A detailed description and discussion of the equipment and methods utilized in a thermoset materials molding plant to automate its operations and make its resultant moldings economical in all respects. Special attention is given to mold costs, mold design, press operation, preheater design, unloader mechanism, and related accessory equipment.

•

How Teflon Improves Surgeons' Heart-Lung Machine. A. W. Byxbee, Gen'l. Mgr., Pacific Coast Div., Raybestos-Manhattan, Inc., Paramount, Calif.

How tough Teflon polytetrafluoroethylene plastic is used to improve the operation of medicine's mechanical marvel — the heart-lung machine that substitutes for the human heart during surgical repair. The properties and qualities of the resin make it ideally suited to its use in the application which employs more than 40 separate plastic parts. A detailed description of the machine and its components, as well as the machine's application, are given.

•

Fabricated (Built-Up) Molds. Carl Zehr., President, Carl Zehr Company, Ashtabula, Ohio.

Low-bulk, low-pressure glass/polyester molding materials offer new possibilities in product design and mold construction. The making of such fabricated molds is discussed, together with their advantages and limitations when compared with costs for conventional high-pressure steel molds. Three current applications utilizing this new mold-making technique are described.

•

Special Notice

Winning entries announced and described for Achievement Awards in Plastics Technology, 1958-1959.

IF PHENOLICS CAN DO IT, PLENCO CAN PROVIDE IT—
AND DOES—FOR **EKCO PRODUCTS COMPANY**

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do their "pan-handling"
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they say, handle with

PLENCO
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Ekco Products, specifying Plenco 385 H.R. Black for handles, shares her confidence. For a higher-than-general-purpose heat resisting compound, this Plenco material possesses an unusually low specific gravity (1.45). More pieces per pound can be made with it, and the formulation is easy on the mold because of its extremely low mold erosion characteristics.

You can be sure that Plenco, with many years of supplying phenolic compounds to critical and competitive industry, has, or can *custom-formulate* the compound *you* need. We invite you to let us demonstrate that.

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1

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- New lows in initial viscosity
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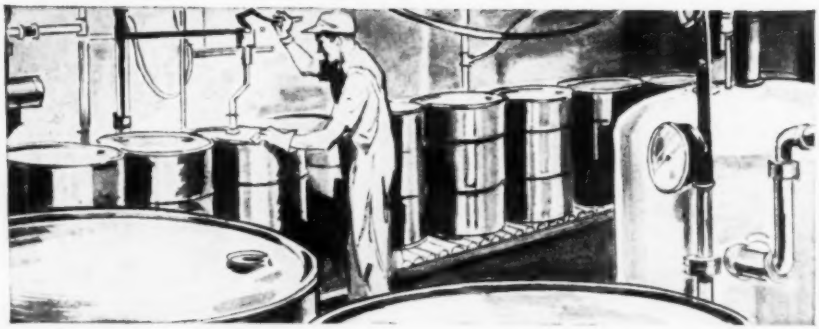
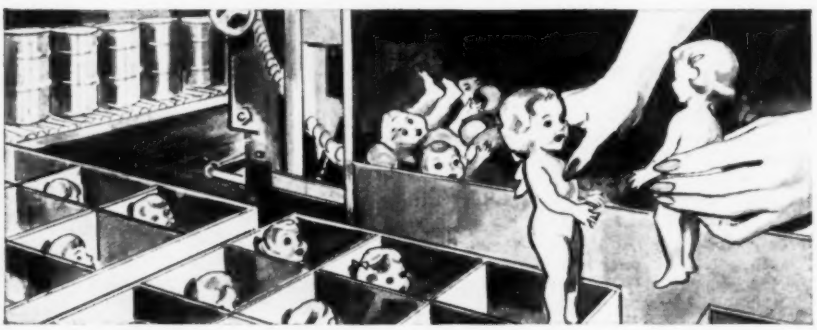
- Improved air release



2

Make better finished products

- New highs in heat and light stability
- High resistance to sulfide staining



National Lead chemical research improves performance of many other vinyl products

National Lead chemical research develops stabilizers to improve all commercial vinyls. There are special stabilizers designed for electrical insulation, garden hose, stereo records, floor tile, strip coatings, upholstery sheeting, shower curtains. National Lead also has gelling agents which control sag, run-off and fabric penetration of plastisols, organosols.

For more about INVIN 85 stabilizer and other chemical developments from National Lead Company, check and mail coupon below. Technical help in their application is yours on request.

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Gentlemen: Please send literature checked below on the chemicals developed by National Lead Research.

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*A trademark identifying a Monsanto service

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because-

1. Better material control
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5. Automatic cycling

Many additional outstanding features of Van Dorn Presses are described in literature available on request.

THE Van Dorn IRON WORKS CO. CLEVELAND 4, OHIO

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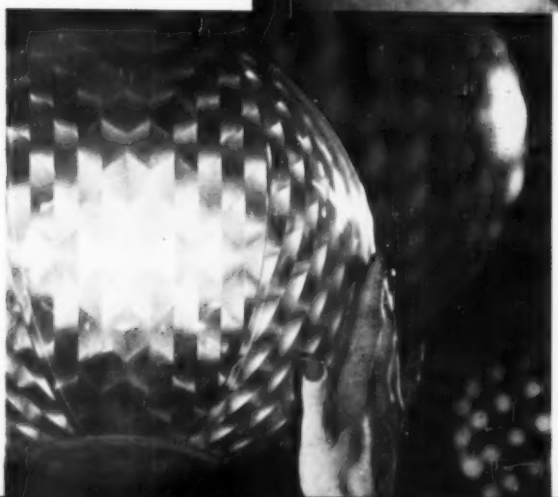
Look to PLIOVIC by GOODYEAR

WANT TO IMPROVE THE AUDIO OF STEREO?

Pliovic has proved its ability to strengthen stereo record grooves and enhance tonal quality. It also improves compound "flow" during high-speed processing, reduces flash, makes possible more efficient production. Can it do the same for you?

NEED A CLEARLY SUPERIOR COMPOUND?

Pliovic is used in many applications where exceptional clarity and maximum flow at moderate temperatures are required—as in the molding of goggle frames. Ideal for calendered or extruded applications which call for critical processing and excellent transparency.

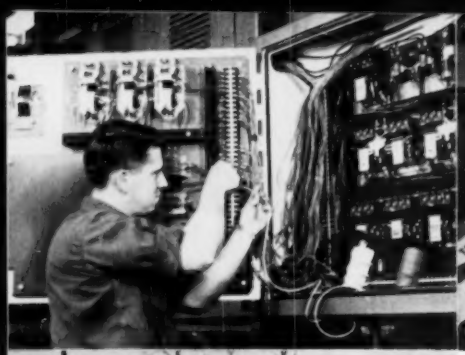


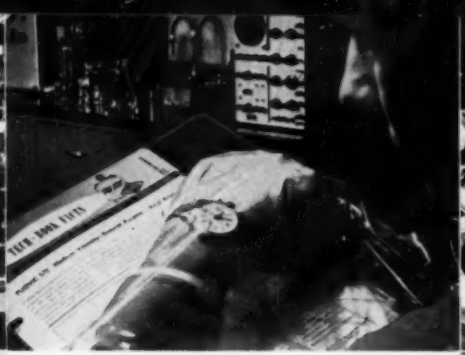
HOW ABOUT A FILM IN 3-D?

Careful compounding and processing of fluorescent pigments with Pliovic produced this strikingly different beach ball made of vinyl film. Pliovic processes readily at relatively low temperatures, minimizes the effects of heat degradation on both resin and pigment, embosses easily and sharply—and provides excellent heat-sealability.

Photos courtesy the following companies: Capitol Records, Inc., Hollywood, Calif., Harte & Co., Inc., New York, N.Y., and American Optical Company, Southbridge, Mass.

For more sales-building ideas with Pliovic—turn the page—





More resins in the Pliovic family with ***more "plus" values for you***

PLIOVIC S50 – a low molecular weight straight PVC resin with the inherent toughness of PVC resins but with flow characteristics comparable to the copolymers. Now being used in stereo record compounds.

PLIOVIC S70 – a general purpose, medium viscosity PVC resin. Well suited for applications requiring maximum flow, sparkling clarity and moderate processing temperatures.

PLIOVIC AO–a copolymer PVC dispersion resin, available in three paste viscosity grades. In plastisol formulations, it offers gradual gel properties that begin at relatively low mold temperature.

PLIOVIC DB90V – a high molecular weight PVC dry blending resin. Provides free-flowing dry blends, uniform fluxing rate and smooth, homogeneous vinyl products.

PLIOVIC DB80V – offers the same quality features as DB90V, but has lower molecular weight. Can be fluxed at temperatures 5 to 10 degrees lower.

PLIOVIC EDB90V – a dry blending resin on the resin interchangeability list of Underwriters' Laboratories, Inc. This high-purity PVC flows freely, disperses readily – can be fed right into extrusion equipment.

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More information and complete technical assistance on all PLIOVIC resins are yours for the asking. Simply call the Goodyear Chemical Division Field Office nearest you.

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CHEMICAL DIVISION

Pliovic–T.M. The Goodyear Tire & Rubber Company, Akron, Ohio

Photos courtesy of the following companies: Royal Electric Corporation, Pawtucket, R. I.; United Plastics & Development Company, Kent, Ohio; Akron Presform Mold Company, Cuyahoga Falls, Ohio; Bedminster Sound Corp., Belleville, N. J.

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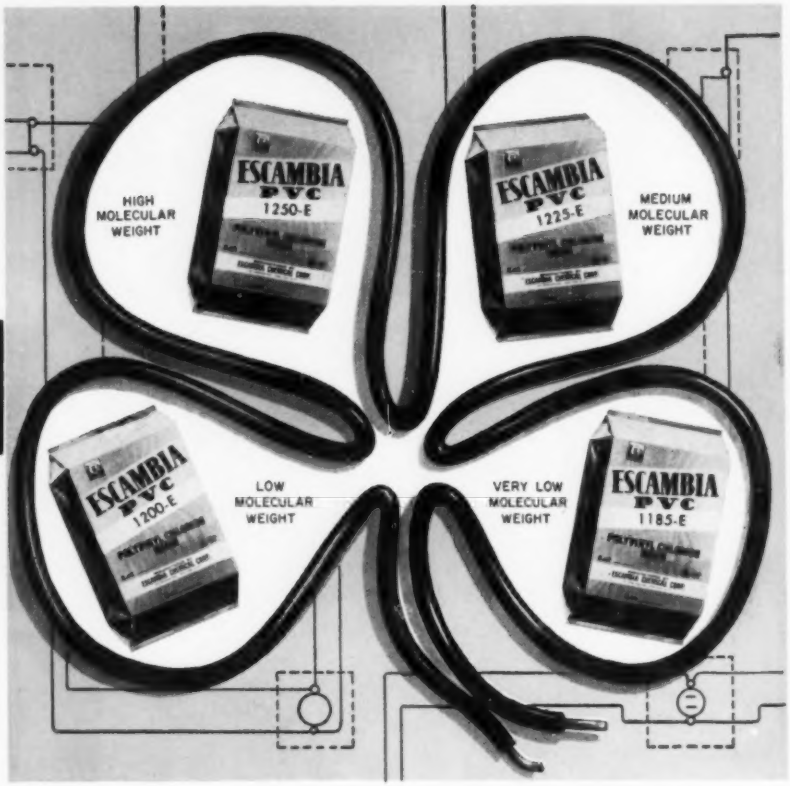

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- **Freedom from fines**
- **Outstanding heat stability**

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What's New in Processing

Baker Castor Oil Co. has come up with a new system for producing low-cost rigid and semi-rigid urethane foams which are said to have superior fire resistance, self-bonding properties, and resistance to shattering under load over polyether- or polyester-based foams. The Baker method substitutes castor polyols for these components in the catalyst, thereby obviating the need for proportioning pumps and heating equipment which are often needed to combine a viscous prepolymer with a low viscosity catalyst. The recently-available **DeVilbiss** gun, which was described here in October, can be used to spray low-density (1.5-2 lbs./cu.ft.) foams which will adhere to vertical surfaces without sagging.

•

A new polyethylene film processor has joined the ranks—**Phillips-Joanna Co.,** a firm jointly owned by Phillips Petroleum Co. and Joanna Western Mills Co. Located in Chicago, P-J will shortly open a plant in Ladd, Ill., for the production of linear and conventional polyethylene films for the packaging industry.

•

Colorite Industrial Dyers of New York City has developed a new process which enables them to dye Teflon parts and wire, and to color-code epoxy printed circuit boards. The new method utilizes a wide range of color combinations, many of them specified by RETMA, which will not affect the dielectric properties of either material.

•

Kautex-U.S. Sales Co., Inc., has completed patent negotiations with Plax Corp., Owens-Illinois, and Kautex-Werk, whereby the processor no longer has any patent problems nor does he pay continuous royalties when purchasing a Kautex machine. He becomes a licensee for the use of patent rights of all three firms in the field of blow molding.

•

Recent processing patents included the following: To A. P. Brietzke, assignable to Northern Engraving & Mfg. Co., for a method of making printed circuits — **2,874,085**. It involves silk-screening an electrically non-conductive mask onto a smooth, stainless steel backing plate; electroplating and removing the mask; pressing a sheet of uncured thermosetting resin to the plate; curing the resin; and removing the embedded, cured sheet.

R. B. Bridge, T. E. Marshall, and W. A. Von Wald, Jr. to the U.S. Navy on a method of making a Plastic Encased Article — **2,873,482.** A thermoplastic, cylindrical casing with a relatively high temperature coefficient of expansion is molded about an object, removed, and longitudinally stretched to move the interior ends. This produces a clearance between them and the object, which is maintained while cooling to below 180° F.

J. K. May and C. E. Maynard to Pro-Phy-Lac-Tic Brush Co., a method of decorating articles formed of thermosetting materials — **2,874,419**. Intended primarily for tableware, the method comprises applying the desired design to a sheet of absorbent paper with an ink, the pigment vehicle of which contains a compatible resin. The sheet is impregnated with a solution of the molding resin to form a foil which is then dried and trimmed to encompass the design. The molding powder is compressed into a preform which is heated and against which the foil is pressed. Molding fuses the two.

•

The following articles on processing appeared in European publications this past April. The first is from Industrie Plastiques Modernes, and the others are from Kunststoffe. **"Molding Polypropylene"** by R. Hanna and J. Lomaz pointed out that design and thickness of the article to be molded, type of feed passages, gating, and mold temperature are decisive factors. Plasticizing capacity, due to its higher specific volume, is 20% less than styrene.

"Scientific, Technical, and Economic Principles of Chipboard Manufacture" by W. Klauditz is a comprehensive review of chipboard manufacture.

"Efficient Production of PVC Rainwear by High Frequency Welding" by A. Draschler describes the setting up, organization, and operation of a high-frequency welding shop for the manufacture of plastic rainwear.

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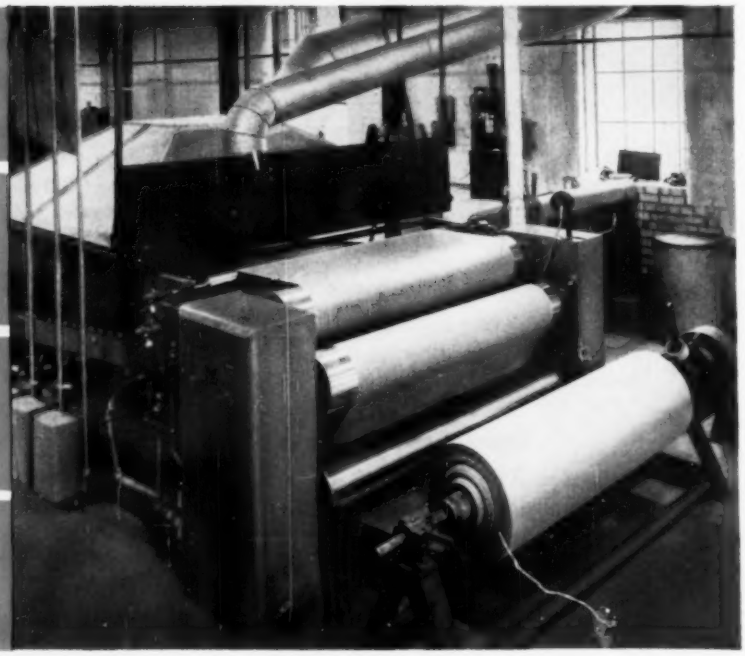

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PLASTICS
THE MAGAZINE OF APPLIED ENGINEERING
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EDITORIAL:

The Danger of American Complacency

Is American industry becoming too complacent and self-satisfied? Is the American manufacturer not quite as good as he thinks he is? Is American industry prepared to meet the challenge of foreign competition?

These questions were posed at the 15th annual conference of the American Society of Industrial Designers, held in New York City last month. The conference sessions had active participation from both business and industry leaders, and some of the thoughts expressed were provocative, to say the least.

•

In his talk, G. H. Whidden, vice president in charge of marketing for Bulova Watch Co., said: "There's too much fiddling around, and what might be called narcissism on the part of the manufacturer. What has happened to the urge to compete, and the willingness to get down to work? It does appear to be 'the age of the goof-off'. The best way American industry can meet the challenge of foreign competition is to 'go back to work'."

The thoughts expressed in Mr. Whidden's talk were sobering, but the average reaction by attendees at the meeting was, "Sure, this applies to some American industries and to American workers in general, but it's not true for myself, my company, or my industry." And we know that our readers will quickly say that it doesn't apply to the American plastics industry which is youthful, growing, and dynamic. Every plastics company is on the ball and alert to all the new opportunities that are constantly presenting themselves.

But is it really? Shouldn't we use this month before we enter the "Scrambling Sixties" to stand back and view ourselves logically?

•

While the American plastics industry still is the international leader in the plastics field, is its lead still as great as it was after the end of World War II? Didn't polypropylene plastics get their start in Italy? Haven't the Germans been doing new things with plastics processing machinery? How about the new developments in plastics processing techniques being done in Great Britain?

Isn't it time that we in American plastics began to really buckle down? Haven't we all been marking time, satisfied with American leadership in plastics—while the rest of the world has been busy catching up with us in general (and even surpassing us in some respects)?

The American plastics industry would do well to adopt our editorial theme, "Stillness is just another aspect of death." Everything, be it a company, industry, or publication, has a potential for improvement. This should be our New Year's resolution for 1960!

Season's Greetings

Concluding our fifth year of publication, PLASTICS TECHNOLOGY pauses to extend Season's Greetings and best wishes in the coming year to its readers and the entire plastics industry.

Arthur M. Merrill
Editor

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Dibutyl Sebacate	0.935	7.9	Vinyl Resins, Cellulose Acetobutyrate, Synthetic Rubbers, Rubber Hydrochloride, Polymethyl Methacrylate	Low Temp Flexibility, Excellent Aging Qualities, Non-Toxic
Dimethyl Sebacate	0.986*	3.54 @30°C	Vinyl Resins, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate, Acrylic Resins	High Solvency and Efficiency, Wide Compatibility, Concentrated Source of Sebacyl Radical
Dioctyl Sebacate	0.913	17.4	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate	Excellent Low Temp. Flexibility, Low Volatility, Excellent Soapy Water Resistance, Good Electricals

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This Month In Brief

"The Danger of American Complacency" is the title for this month's Editorial. This "fat cat" attitude can be blamed on American workers, American companies, and American industries in equal measures. While we have all been sitting back and admiring ourselves, the rest of the world has been busy catching up. This applies to plastics, as well as to other fields. Item in point: satellites. It's time we all got back to work!

The other side of the public relations coin is the subject of the Guest Editorial this month. Taking sides against Lucien Greif's views in his Guest Editorial, "I've Got a Secret?" in our October issue, Harold Schor says a sound publicity program is a sales aid for any company, not an obligation for them to reveal all their legitimate secrets. What do our readers think when they compare the two opinions? Would they care to have us expound on our views and show how these seemingly divergent views can be resolved?

Some notes on the Technical Articles appearing in this issue follow:

The lead article, "Extrusion Molding," describes and discusses recent developments in both domestic and foreign extruders that emphasize the important advantages of screw plasticization for plastics materials.

"Stabilization of Linear Polyethylene Against Ultra-Violet Light" shows that combinations of antioxidants and U-V light absorbers provide effective stabilization of resulting products to outdoor exposure.

"Evaluating Plastics for Compression Molding of Phonograph Records" tells how the molder can compare plastics materials, molding cycles, and molding conditions for this application.

"Nondestructive Quality-Control Tests on Finished Reinforced-Plastic Parts" gives the molder a practical, simple test method for checking his production operations.

The Engineering Forum column on Injection Molding deals with "Mold Finishes for Polyolefins" -- a contributed discussion by Al Spaak, of W. R. Grace, that compares the advantages and applications of chrome plating, vapor honing, sand blasting, die engraving, and photo-arc engraving of mold surfaces, and the effects they have on parts made in such molds that reflect their surface finishes in the resultant moldings.

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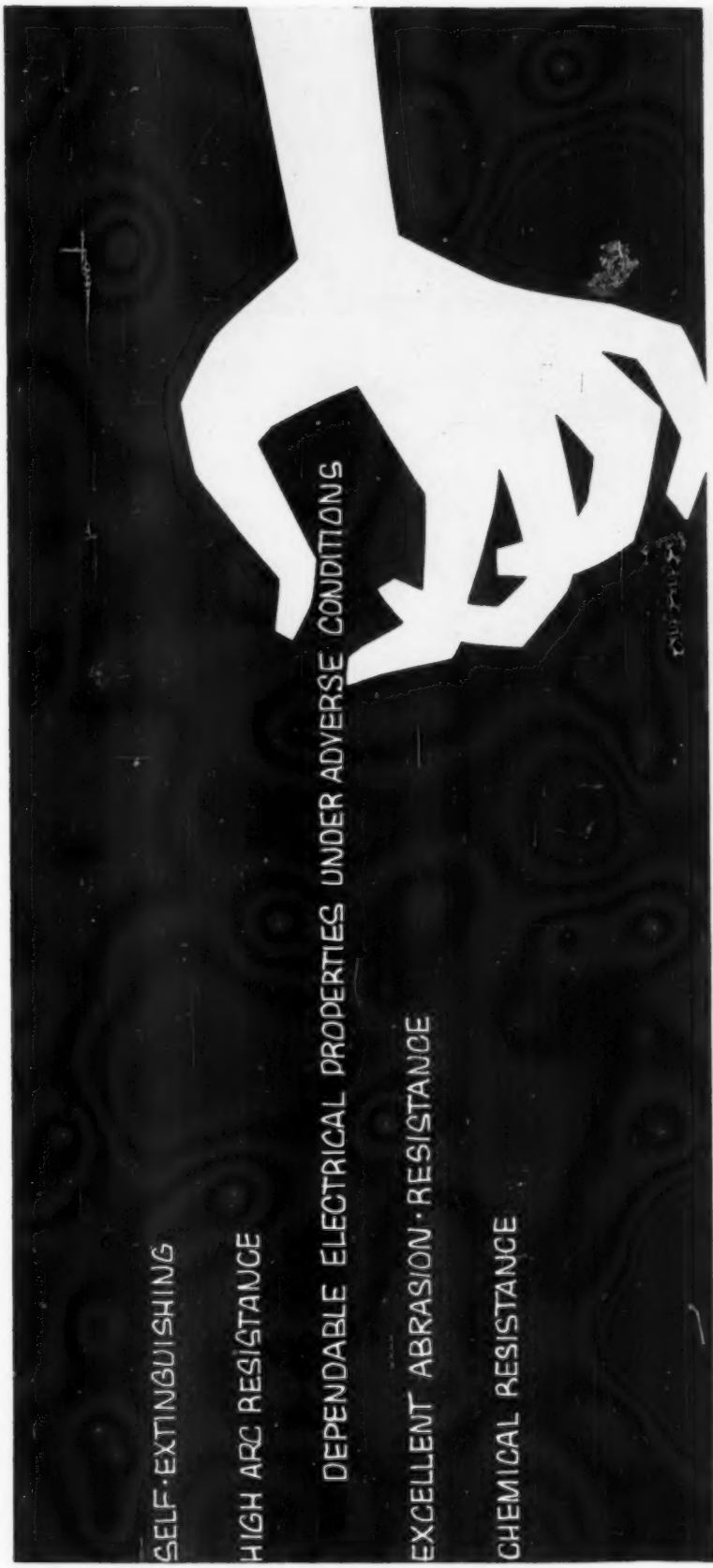

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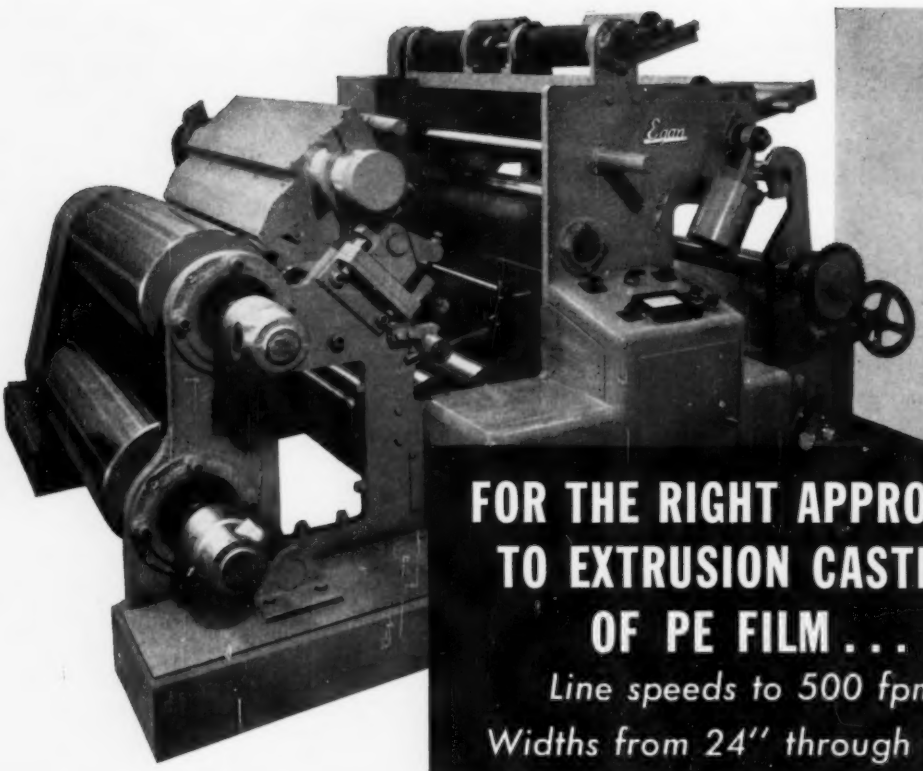

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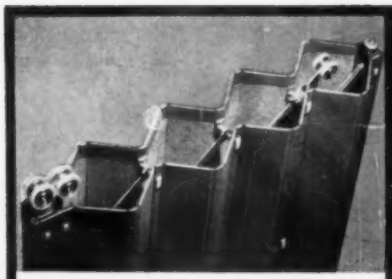
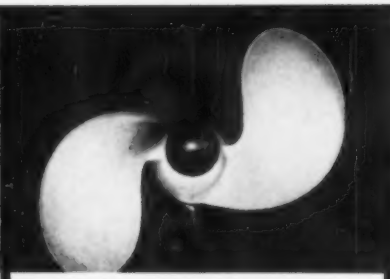
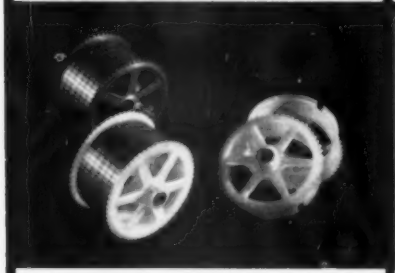


SNAP-ON FASTENERS for accordion-door covers and quiet roller wheels are made of ZYTEL, which provides resiliency and resistance to impact and abrasion. (Molded by Flambeau Plastics Corp., Baraboo, Wis., for Hough Mfg. Corp., Janesville, Wis.)



OUTBOARD-MOTOR PROPELLER, made of Du Pont ZYTEL, is tough, durable and noncorrosive even in salt water. It adjusts its pitch automatically. Use of ZYTEL makes possible considerable cost savings. (By Grish Brothers, St. John, Indiana.)

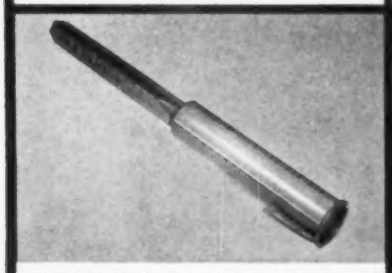
POWER-MOWER THROTTLE is molded of Du Pont ZYTEL 101 in several colors, taking advantage of this resin's toughness, wear resistance, chemical resistance and light weight. (By Western Control Corporation, Wichita, Kansas.)



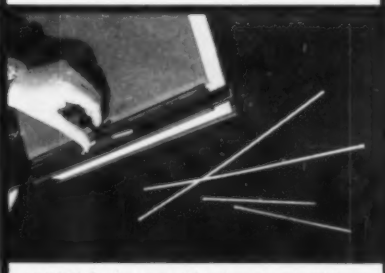
SPROCKET FOR TIME CLOCK has high strength, high fatigue-endurance limit, light weight. Injection-molded of ZYTEL, it cuts costs, simplifies assembly. (Molded by Hamilton Plastics Molding Co. for Cincinnati Time Recorder Co., both of Cincinnati, O.)

SPINNING REEL operates smoothly, is exceptionally light in weight, easy to handle and durable. Almost all parts are molded of Du Pont ZYTEL. (Molded by Plano Molding Co., Plano, Ill., for Waltco Products Incorporated, Chicago, Illinois.)

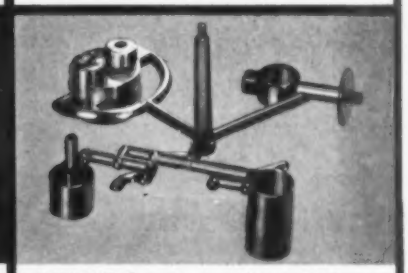
"SQUIRREL-CAGE" BLOWER is used in refrigerators. Made of Du Pont ZYTEL, this intricate, thin-walled molding has high strength, and is unaffected by the low temperatures encountered. (By Torrington Manufacturing Co., Torrington, Connecticut.)



SAND SPIKE fishing-rod holder is made of two parts of orange-colored ZYTEL. It is tough, corrosion-resistant and light in weight. (Molded by Du Bois Plastic Products, Inc., Buffalo, New York, for The Gliebe Co., Brooklyn, New York.)



POSTS for loose-leaf binders that hold business records are made of tough, flexible ZYTEL, easily threaded into holes. The posts permit greater sheet capacity, flatter opening than posts of other materials. (By Wilson Jones Co., Chicago, Illinois.)



AIR PUMP for aquarium has molded cap, bushings and cam actuator made of Du Pont ZYTEL. These parts offer high strength and abrasion resistance . . . make possible economies in production. (By Eugene Danner, Brooklyn, New York.)

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Versatile ZYTEL nylon resins offer the designer a combination of properties that can be used to improve the performance and lower the cost of almost any mechanism. The high strength, abrasion resistance and low friction of ZYTEL make it an outstanding gear and bearing material. It is resistant to heat and chemicals. It can be economically injection-molded in intricate one-piece configurations, with moldings held to close tolerances. The result: reduction in inspection cost, material cost, fabrication cost.

Many molders have the experience to supply you with parts of ZYTEL nylon resin in quantity to your exact specifications. For your copy of a booklet, "Designing with ZYTEL nylon resins", write to: E. I. du Pont de Nemours & Co. (Inc.), Department FF-12, Room 2507Z, Nemours Building, Wilmington 98, Del.

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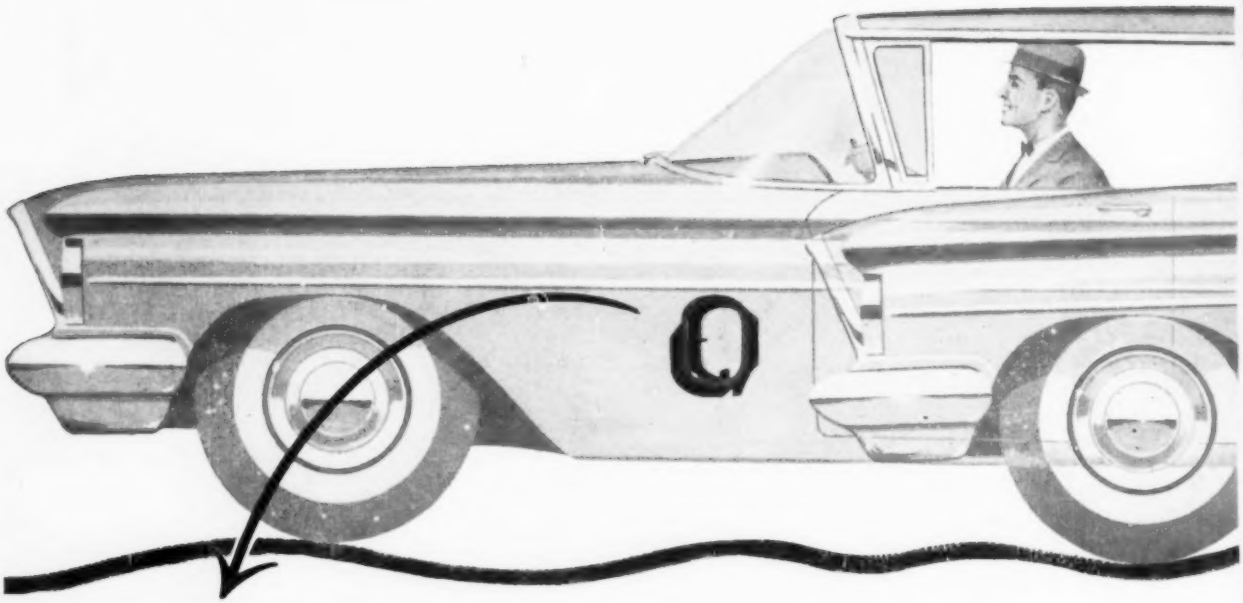
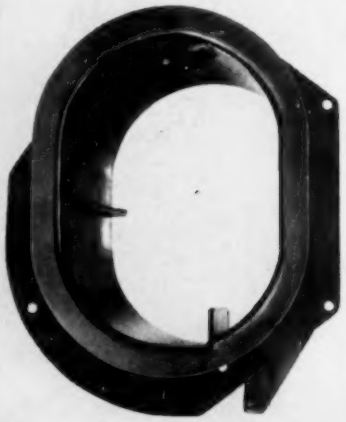
IMPACT STYRENE

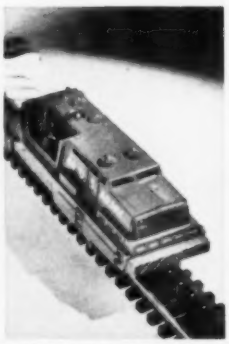
...injection molded air ducts



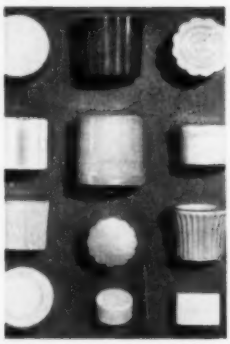


There are two of these impact styrene ducts in each car. Diagram shows their position. Look for them on the new models. They are molded by Wolverine Plastics Inc., Milan, Mich.

Other styrenes in this series



High impact and fast cycle. TMD-6000 is a high impact material for a wide variety of uses—especially where mold filling is critical. It combines set-up speed with plasticity . . . flows easily in large, complex parts, yet sets quickly. (Toy railroad car molded by The Lionel Corporation.)

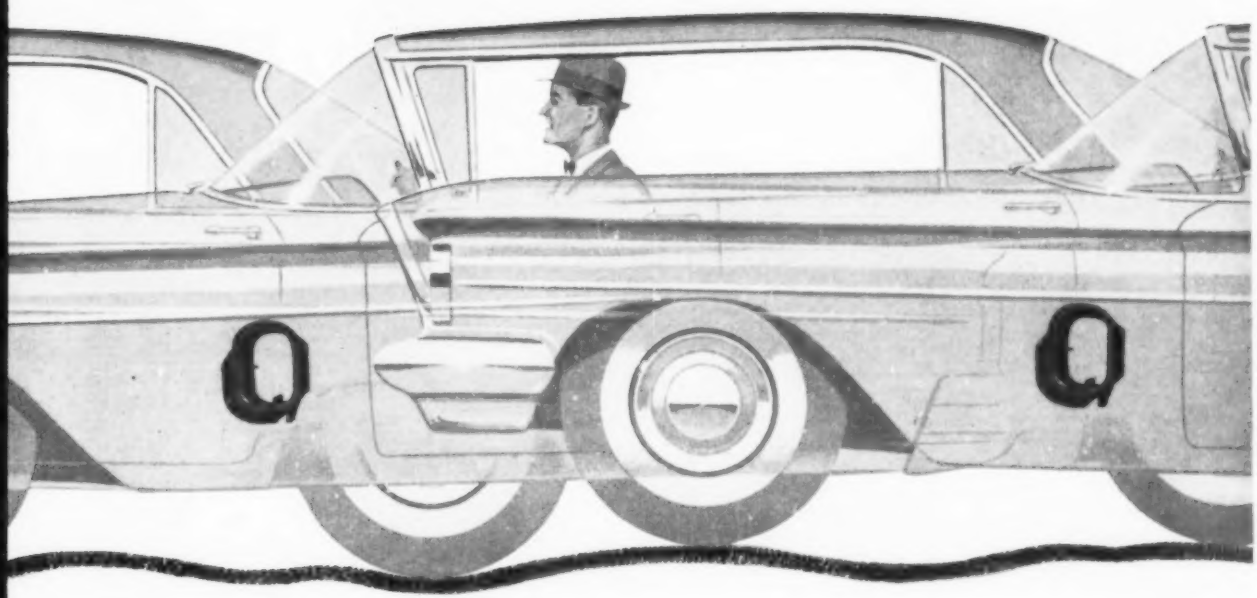


Medium impact, broad molding latitude. In fact, BAKELITE Brand styrene TMD-9001 is formulated for the widest molding latitude in its class. It is especially good for complex shapes that tax machine capacity. Molded in thin sections, it can be stapled with practically no blushing. (Closures molded by Mack Molding Company, Inc.)

Medium impact and heat resistance. TMD-8000 offers excellent gloss and dry colorability. Production experience indicates that it can be broached without crazing and has high scratch resistance. (Radio cabinet molded for Motorola, Inc. by G. Felsenthal & Sons, Inc.)

ON THE GO!

in Detroit's latest cars



This year's automobiles give impact styrene a tough new job. This air duct has to withstand strain, vibration and heat during both installation and use.

BAKELITE Brand impact styrene TMD-5161 was chosen for its outstanding resistance to both heat and impact—and the molding advantages brought lower costs, faster production. Notice this air duct's intricate design—TMD-5161 is free-flowing enough to fill large complex molds. Rigid but tough, it also takes inserts and self-tapping screws.

TMD-5161 is just one of a series of impact styrenes for injection molding offered by Union Carbide Plastics Company. They are available in a range of impact strengths and heat deflection temperatures. Various formulations offer combinations of properties that should closely fit your needs.

To help in making your choice, the latest issue of MOLDING NEWS, "the Test of Impact," gives plastics fabricators detailed information and suggestions on the use of these materials. Write Dept. LQ-02G, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 E. 42nd Street, New York 17, New York. In Canada, Union Carbide Canada Limited, Toronto 7.

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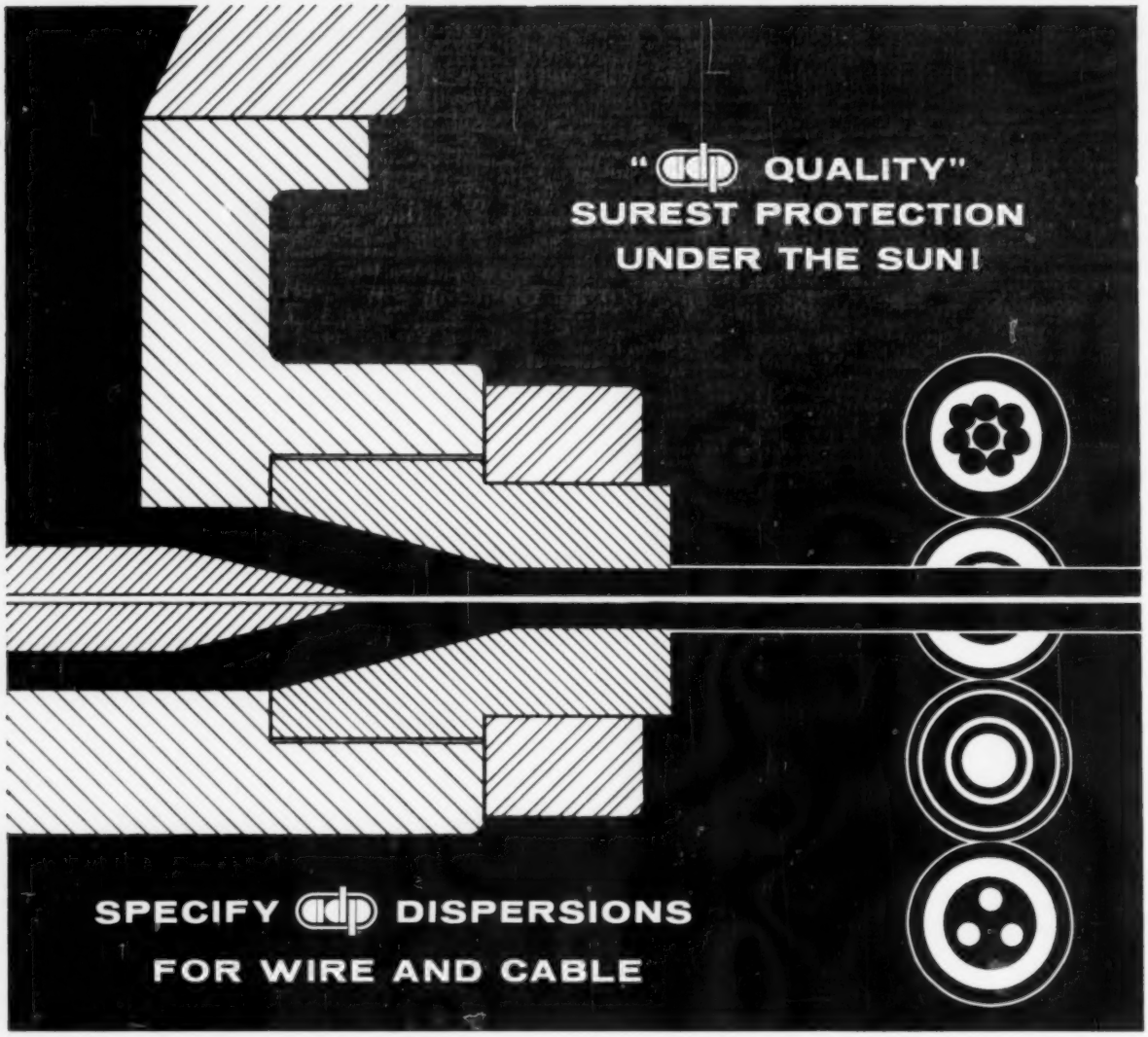
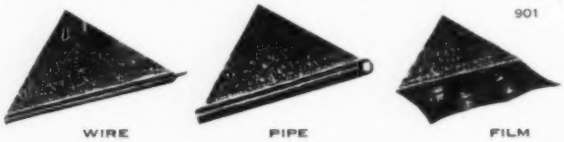


Only a uniformly fine dispersion of carbon black can assure year after year protection to plastic insulated wire and cables that are exposed to sunlight. Maximum resistance to harmful ultraviolet radiation depends upon the concentration of carbon black used, its particle size, and the thoroughness with which it is dispersed. Uniform dispersion of microscopic carbon black particles in "ADP Quality" concentrates will control oxidation and subsequent degradation of plastic wire coating giving you the highest product quality.

ADP concentrates of carbon black assure equally superior protection for plastic filament, pipe, and blown or flat film extrusions. In addition to carbon black dispersions in polyethylene, polyvinyl chloride, polystyrene and other resins, Acheson also supplies "ADP Quality" dispersions in electrical code colors. Send for a sample "ADP Quality" dispersion and see the difference . . . or let Acheson specialists work with you to solve your special vehicle or resin dispersion problems.



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U.S.I. POLYETHYLENE NEWS

A series for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

DECEMBER, 1959 — U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation — 99 Park Ave., N. Y. 16, N. Y.

Packaging Notes

A handy polyethylene pump for inflatable items has been marketed by a California manufacturer of air matresses and beach toys.

The pump consists of an open polyethylene bag with a reinforced hole at one lower corner. The polyethylene pump is used by attaching it to the valve of the inflatable item, and fluffing the bag open. Then the top is closed by rolling it. Finally, the bag is squeezed down and rolled to force the air from it into the inflatable item.

Compact First Aid Kits of Polyethylene are being marketed. The inexpensive kits are specially designed for marine use, but outlast metal containers any place where corrosion is a problem. The kits are water, rust, and mildew proof. They also float. The kits are available in two sizes and contain bandages, tapes, ointments, and scissors normally found in first aid kits.

Wholesale jewelers use polyethylene bags to ship their merchandise. The tough polyethylene bags not only give better inspection advantages but they also eliminate heavy returns of jewelry formerly scratched in shipping.

Use of a heat-sealed strip of polyethylene has greatly reduced the difficulty of opening sealed polyethylene bags. This application of polyethylene is now being used by a cake mix producer for easy opening of his package's inner bag.

A ½ inch strip of polyethylene is welded along the width of one side of the bag by a thin line of heat-sealing. It runs 1 inch below the top of the bag and extends ¼ inch from each edge of the bag. When the free end of the strip is pulled, the polyethylene bag tears with it along the heat-seal line.

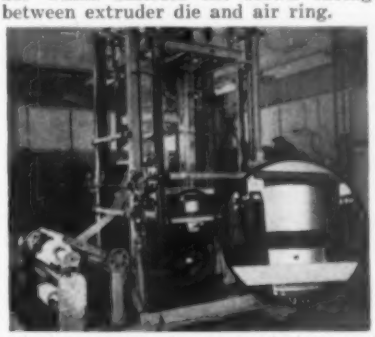
DO YOU HAVE a new polyethylene packaging development you'd like the industry to know about? Make it routine to send your information on new developments to U.S.I. POLYETHYLENE NEWS.

Address the Editor,
U.S.I. POLYETHYLENE NEWS, U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corp., 99 Park Avenue, New York 16, N. Y.

New U.S.I. Technique Improves Optical Properties of Blown Polyethylene Tubing

Annealing Chamber Increases Light Transmittance, Reduces Haze

The U.S.I. Polymer Service Laboratory has developed an annealing chamber or "chimney" technique which results in significant improvement in clarity and gloss of blown polyethylene tubing, with practically no sacrifice of physical strength. The method, involves installation of a chamber which encloses the blown tubing between extruder die and air ring.



Polyethylene tubing has improved clarity and gloss when produced with new U.S.I. annealing chamber technique. Close-up view shows "chimney" in place between extruder and air ring.

Unit is easy to install

The chimney may be made of wood, glass or insulated metal. It should be constructed in two sections or hinged to permit installation during extrusion . . . thus eliminating need for rupturing the "bubble" when threading film through the annealing chamber.

Height of chimney is an important factor. Optimum results are usually obtained with a 6 to 10" chimney height. While ratio of chimney diameter to die diameter is not critical, it should be held between 2:1 and 3:1. For example: a 3" die would require a 6 to 9" chimney diameter.

An evaluation of PETROTHENE P-200-25 resin using this technique revealed:

Optical Property	*No Chimney*	*8" Chimney*
Transmittance	30%	70%
Gloss	7%	11%
Haze	11%	4%

No significant change was noted in impact strength. Elmendorf tear tests showed that a directional strength balance was brought about by adding the chimney. Tear values increased in the transverse direction and decreased in the machine direction. Yield, break and elongation were essentially unchanged.

Work on this new technique is continuing at the U.S.I. Polymer Service Laboratory, where your inquiries are always welcomed. If you have special problems, U.S.I. engineers will gladly offer their assistance. You are also invited to write for a Technical Data Sheet describing the new process.

Polyethylene "Socks" Used in Causeway Construction

A causeway between Miami and Miami Beach will consist of a number of bridges connecting a series of man-made bulkheaded sand islands. The company building the causeway has found a unique construction use for polyethylene film "socks."

When the sheetpiles that form the bulkheads for the man-made islands are in place, the top pockets or slots between adjacent piles are grouted with mortar to make the wall absolutely tight and prevent loss of sand fill. To prevent leakage of mortar in this operation and to save time in building forms, the contractor devised polyethylene "socks" that fit in the slots to be filled.

A small amount of mortar is placed in the bottom of the "sock." The sock or bag is then allowed to sink into place in the slot and the rest of the mortar is then poured into it. The method is described as an efficient and effective way to seal joints in precast concrete structures, whether in water or in the dry.

Polyethylene is Vacuum Formed on Planting Pots

A midwest company has developed a process for vacuum forming 1 mil polyethylene film around peat moss planting pots.

The pots, which are used to start flowers, vegetables and nursery stock of all types, shorten the plants' growing period, and at the same time, improve their quality.

Photo courtesy A. O. Reynolds Co., Lebanon, Indiana

This vacuum forming of polyethylene has significantly improved the pots' strength by increasing their resistance to water damage. The polyethylene jacket insures a constant supply of water for the plant in the pot. When the plant and its pot are ready to be put in the ground, the polyethylene film strips off easily.

These pots, now being field tested extensively by greenhouses and commercial growers, are molded by drying peat moss paper slurry. The polyethylene film is then vacuum-mated to them.

U.S.I.

Vol. IV, No. 6

POLYETHYLENE PROCESSING TIPS

PROPERTIES THAT AFFECT GREASEPROOFNESS OF POLYETHYLENE COATINGS

As used in the paper coating industry, the term greaseproofness generally refers to conformity of a polyethylene coating with Military Specification MIL-B-121A. This specification defines the grease resistance of polyethylene-coated paper used to package material which is grease-coated for long-term storage.

Under this specification, greaseproofness is tested by measuring the resistance of polyethylene-coated paper to a turpentine solution of a dyed grease. Test conditions require 24 hours exposure to the solution at a specified temperature and relative humidity. To meet the specification, all samples tested must be free of dye color on the uncoated side of the paper at the conclusion of the test period.

Although this specification was drawn up to satisfy the stringent requirements of military applications, it is also employed to define the grease resistance of polyethylene-coated paper to be used for industrial and food applications. However, there are many cases where the requirements of MIL-B-121A may be reduced and still be entirely satisfactory. How far these requirements may be lowered can best be determined through actual tests with the item to be packaged.

Importance of Resin Density and Melt Index

One resin property having an important effect on the greaseproofness of a coating is density. Generally, as resin density is increased from 0.915 to 0.930 and higher, the grease resistance of a polyethylene coating of a given weight improves considerably, as shown graphically in Chart 1. Polyethylene permeability to gases and liquids is similarly affected by density, as previously discussed in this series (U.S.I. Polyethylene Processing Tips, Vol. II, No. 2, and Vol. IV, No. 3). This is to be expected since greaseproofness is one aspect of permeability.

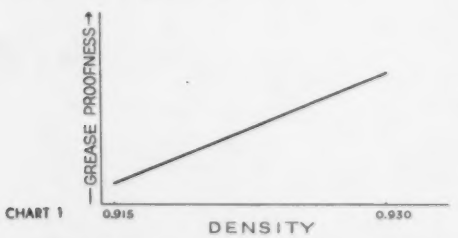


CHART 1

Melt index also influences greaseproofness, decreasing melt index resulting in improved grease resistance. However, melt index has less of an effect than density. Chart 2 shows this relationship.

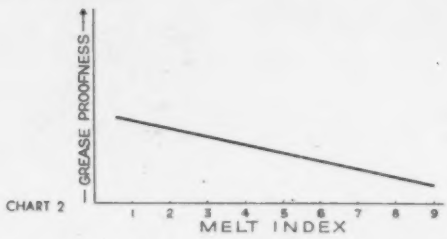


CHART 2

Balancing of Effects

But the paper coater seeking to produce grease-resistant polyethylene coatings cannot consider the effects of density and melt index on grease permeability alone. He must also consider the influence of these properties on the economical operation of his equipment. Such problems as increasing neck-in and curl resulting from the use of higher-density resins must be evaluated before selecting a resin for a given application.

Influence of Coating Weight

Greaseproofness of the finished sheet also depends on the weight of the polyethylene coating applied to the substrate. The greater the coating weight or thickness, the better the grease resistance. With a thicker coating or a resin of higher density, the likelihood of individual paper fibers fracturing the film surface during coating is reduced. With very heavy coatings, however, curl is increased and slower speeds are required.

What Type of Coating?

Theoretically, a heavy enough coating of any polyethylene resin will produce a sheet which will pass MIL-B-121A. But from a practical standpoint, the lowest coating weight which gives the most coverage per pound of polyethylene is an obvious ideal. This can be accomplished by selecting the highest-density resin which has good processibility, acceptable adhesion, and reasonable neck-in, and permits high operating speeds.

Economical coatings meeting MIL-B-121A requirements can be produced with PETROTHENE® coating-series resins. These resins usually yield a proper balance of properties wherever greaseproofness is the primary objective. Where other objectives are predominant, U.S.I. Technical Service Engineers will be glad to recommend the proper resin for your application. They'll also work with you on any processing problems you have.

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DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DETERMINING IN-USE TOUGHNESS OF MOLDING MATERIALS REQUIRES STUDIES OF VELOCITY EFFECTS

The terms "impact resistance" and "toughness" are difficult to define, and even more difficult to measure in meaningful terms. In general, impact resistance is considered to be the ability of a material or object to withstand a shock loading, or a stress delivered at a high rate of speed. While toughness also describes a "more-or-less" degree of resistance to breaking, it does not relate to any particular speed, or range of speeds, of loading.

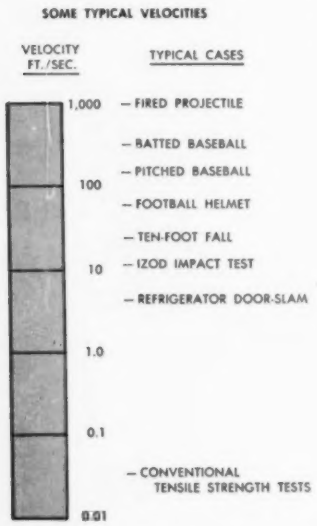
However, since the strength properties of plastics are time dependent, they will vary as the velocity, or time of stress application varies. *These variations are extremely important to the designer or plastics engineer, particularly when the in-use strength of a plastic material is critical to the successful operation of a product or mechanism.*

Some plastics are more sensitive to changes in impact velocity than others, but most have a critical velocity above which they will be brittle and below which they remain strong and ductile. Thus, in selecting a material for design purposes, it is important to know the relative resistance of the plastic to impact AT VELOCITIES OF THE SAME ORDER AS THOSE WHICH THE PLASTIC WILL BE MOST LIKELY TO ENCOUNTER UNDER USE. In-use impact velocities range from about 1 ft./sec. to many hundreds of feet per second. At left (below) are some typical impact sources and the average velocities encountered. The standard Izod impact test is made at about 11 ft./sec. and provides only screening data which is inadequate for most design purposes.

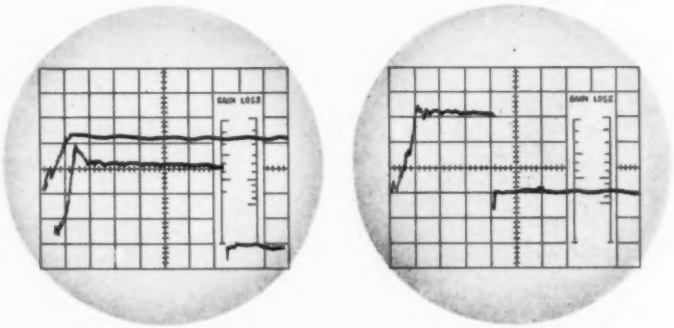
For example, data gathered during a study by Dow Plastics Technical Service Engineers on high-energy shock loadings of various molding materials indicates that resistance to breakage at low impact velocities is often considerably less than at high velocities, depending upon the particular plastic being tested. In some cases, a regular grade of plastic exhibited greater toughness at high velocities than did a so-called shock-resistant grade of the same material. In other cases, it was found that soft materials were as stiff and tough as hard materials of the same general type, under high velocity impact. A typical set of high velocity oscilloscope-recorded stress-strain data from this study is illustrated at right (below).

Further, this study illustrated the strengthening effect of geometry of the molded part, and of molecular orientation which occurs during molding. One plastic material which the Izod impact test interpreted as brittle, with little impact resistance, proved to be highly resistant to high velocity impact *when tested in its final molded form.*

These tests are part of a continuing study by Dow engineers to provide information and assistance to designers and plastics engineers in the most effective selection and use of plastics materials. Some of the results of this study are periodically reported in articles such as this, while detailed results and data are available in more complete form on request.



The range of impact velocities encountered in actual use by plastic materials, and typical impact sources which generate them.



Oscilloscope patterns of stress and strain to fracture of a typical plastic at high velocity. High velocity tests often completely reverse toughness findings which result from standard low velocity or static testing.

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If your work with plastics materials includes designing, engineering, specifying, or production control, we will be glad to send you a copy. Just use the coupon below, or request a copy on your company letterhead.

Following is a brief description of each of the articles contained in the booklet:

CLASSIFICATION OF DATA

Defined are five basic types of data normally employed for describing the properties of materials. The limitations and use of each type of data are described, together with examples of each.

EXPANDING DATA BASE

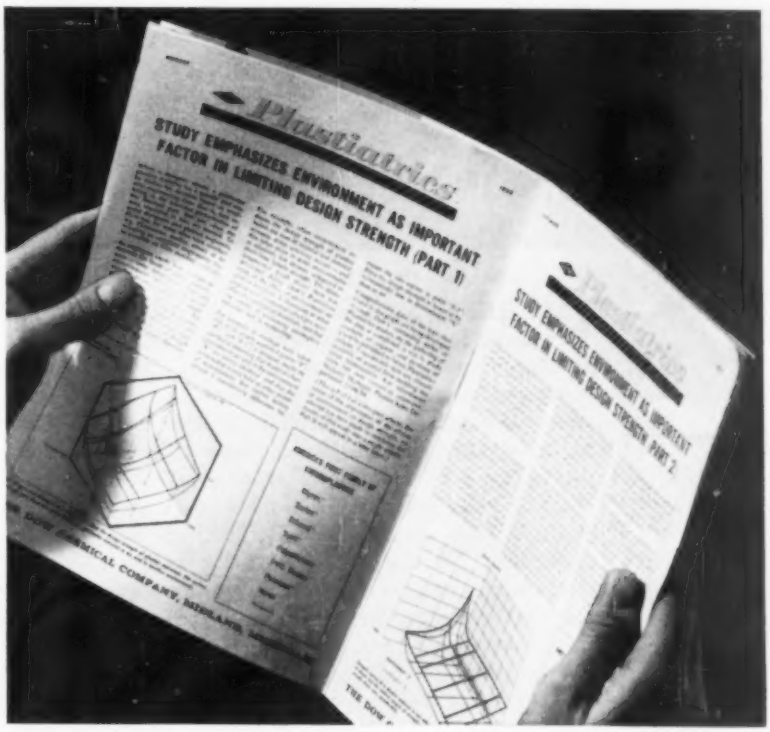
This article carries the discussion above one step further, and provides a detailed example of how quality control data must be expanded to permit screening of materials over a wider range of measurements.

THREE-DIMENSIONAL ANALYSIS

The use of three-dimensional analysis of plastics materials data is shown. The article explains the function of this method as a design tool in determining the full potential value of a plastic under consideration.

ENVIRONMENT STUDY

This two-part article describes the variable effect of environment on the working strength of plastics materials, and the necessity of testing under the environmental conditions to be encountered during actual use of the finished product.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STUDY EMPHASIZES ENVIRONMENT AS IMPORTANT FACTOR IN LIMITING DESIGN STRENGTH (PART 1)
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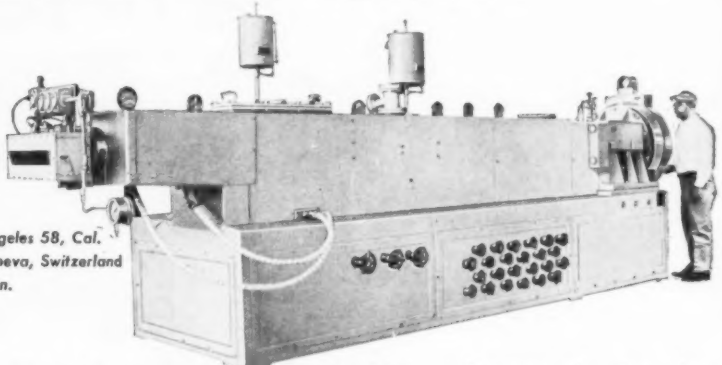

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PLASTICS
THE MAGAZINE OF APPLIED ENGINEERING
TECHNOLOGY

Extrusion Molding

The use of extruders in the production of articles other than continuous profiles.

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E. I. du Pont de Nemours & Co.
Wilmington, Del.

IT has long been recognized that screw extruders are superior to conventional injection molding machine cylinders as plasticizing devices.

The injection cylinder heats plastic granules largely by conduction of heat from the hot cylinder wall. This is a slow process because organic polymers are poor heat conductors. If a practical heating rate is to be achieved, a large temperature gradient must be built up between the cylinder wall and the resin. The material near the walls, therefore, will be hotter by many degrees than the main bulk of the resin. For this reason temperature variations in the resin issuing from an injection cylinder are large, particularly at high through-put rates. These irregular temperature striations, in turn, will induce stresses in the piece, and will cause variations in the dimensions of the molded parts.

When resins having a narrow temperature range between the melting point and the decomposition point are to be processed in an injection cylinder, the cylinder temperature cannot be allowed to exceed the decomposition temperature of the resin. As a consequence, the melting capacity of the cylinder may be limited seriously.

Plasticating extruders overcome these inherent disadvantages of injection cylinders. In plasticating extrusion, the turning of the screw shears the resin. This shear works the polymer and, thus, furnishes a major share of the total heat needed to bring the resin up to the desired temperature. For this reason, an extruder can operate effectively with a barrel temperature which need never exceed the desired temperature of the extrudate.

The screw flights of an extruder continually wipe material off the heated barrel surface and cause it to mix with the resin in the screw channel. As a consequence, a properly-designed extruder can produce larger quantities of melt at a more uniform temperature than an injection cylinder of equal size.

It follows that a considerable incentive exists to extend the application of extruders to the production of finished articles other than continuous profiles. This requires thermoplastics processing machinery which incorporate an extruder to plasticate the resin, followed by a molding or forming device to produce the desired finished articles.

For the purposes of this paper, all such operations are defined as "Extrusion-Molding" process. Various methods by which extrusion-molding operations may be carried out will be described. Although a number of the operations mentioned here have been employed successfully on a commercial scale, few of them could be considered truly established and standard processes at the present time.

Continuous Extrusion

This section covers operations based on continuous extrusion coupled with special take-off devices.

Sheet Extrusion-Sheet Forming

Sheet forming includes all operations in which a sheet is given a three-dimensional pattern. It covers a wide range of operations from embossing to vacuum

forming. Integrated sheet extrusion and forming operations ordinarily might not be considered "extrusion-molding" processes, but logically they do belong in this processing category.

In one such process, which has considerable commercial interest, the sheet of plastic is extruded at a constant rate from the lips of the die and fed onto a conveyor. On the conveyor, the sheet is maintained at a temperature above its melting point. A mold assembly travels with the conveyor at the speed of the sheet, and draws a section or frame of the sheet into the cooled mold where it is given its shape. At the completion of this forming cycle, the mold retracts and the assembly returns rapidly to the starting position to form the next section of sheet (see Figure 1).

If the take-off speed is adjusted so that the sheet advances a distance corresponding to one formed section or frame during each molding cycle, essentially all of the sheet may be formed without waste between frames.

Figure 2 illustrates some pint containers which were formed at our laboratory from extruded sheet of Alathon 31 polyethylene resin using such a technique. The illustration shows these containers before they are trimmed from the sheet.

Historically, it is interesting to note that one of the earliest integrated extrusion-sheet forming operations was developed by the Federal Tool Corp. for the production of picnic plates and dates back to 1952 (1)*.

Blow-Molding

Some blow-molding machines such as those exhibited at the 1958 SPI National Plastics Exposition in Chicago by Kautex-Werk and by Blow-O-Matic Co. (2) employ techniques which are analogous in many respects to those used in the continuous sheet-forming techniques described above. Both of these blow molding machines are designed to produce bottles from a continuous extrusion of a molten tube.

The tube is extruded vertically downward. The mold and blowing mechanism travels downward with the tube as it emerges from the die, clamps around the tube, blows it against the mold wall, and cools it to the desired shape. At the end of this cycle, the mold opens, releases the formed article, and returns to the starting position to form the next section of tubing which had been extruded in the meantime.

Modified Extrusion

This section covers operations based on modifications of the extrusion process. Considerable work has been done in recent years to adapt screw extruders for intermittent delivery in order to use them in molding operations. The following systems have been described in the literature.

* Numbers in parentheses refer to Bibliography at end of article.

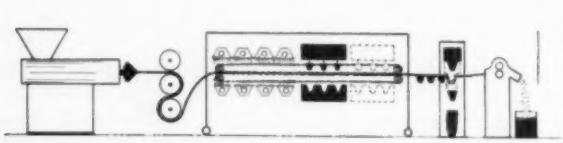


Fig. 1. Integrated extrusion and sheet forming.

Ernest C. Bernhardt was born in Germany in 1923. He received a B.S. in Chemical Engineering in 1943 from Purdue University, an M.S. in Chemical Engineering in 1948 from the University of Delaware, and a Doctor of Engineering in 1952 from the Technische Hochschule, Darmstadt, Germany. He was employed as an engineer by American Cyanamid Co. from 1943-1946, and by Monsanto Chemical Co. from 1948-1950. He joined E. I. du Pont de Nemours & Co. in 1952, and was a member of the Polychemicals Dept. Research Division in 1952-1953. Since 1953, he has been supervisor for Extrusion and Process Development in the Sales Service Laboratory for Du Pont.

Mr. Bernhardt is active in ACS and SPE, and was editor of the SPE book on "Processing of Thermoplastic Materials," published by Reinhold. Dr. and Mrs. Bernhardt have two children, and make their home in Wilmington, Del.

Extruder-Ram Combination

This system employs a screw to melt the resin. The melt is stored in a "reservoir" in front of a retracted ram, and then can be injected by the ram into the mold at a high rate and under high pressure. Two variations of this technique have been employed successfully in special adaptations of injection molding machines.

SEPARATE SCREW AND RAM. The extruder may be used to feed melt to a secondary injection cylinder. One of the first examples of a molding machine operating on this principle was the Jackson-Church machine which employs an extruder to plasticate a given quantity of resin for subsequent injection into a mold by a separate ram (3). More recently, the Reed-Prentice "Jet Flow" machine employs a similar principle, but locates the secondary ram within the rotating screw (4).

In designs incorporating screw and ram combinations, it is important to take care that fluid polymer does not enter into the clearance between the reciprocating ram and the surrounding cylinder, and that the polymer immediately ahead of the ram does not stagnate.

RECIPROCATING SCREW. A considerable number of injection machines have been built in Europe, employing an injection cylinder that consists essentially of a

screw extruder in which the screw performs an axial as well as a rotary motion (see Figure 3). The screw acts both as the plasticator and as the ram. When the screw is in the retracted position, a reservoir of melt exists in front of the screw.

During the injection cycle, the screw is advanced forward by a hydraulic mechanism, and discharges this melt through the nozzle at high speed and pressure (5). Through proper screw design, or by the use of a special check valve on the screw, excessive leakage and backflow down the screw channel during the forward injection stroke of the screw may be avoided. The continued rotation of the screw at the end of the injection cycle advances melt for the next shot, and pushes the screw back into the retracted position.

A modified machine, employing the same reciprocating screw injection mechanism, but using a multiple mold turret, rather than the conventional single mold and clamp was announced recently (6).

Injection machines employing a twin-screw extruder with reciprocating screws in place of the single-screw unit are the basis of another European design (7). Recently, a modification of this twin screw machine was introduced in which the reciprocating screw does not discharge the melt directly into the mold, but instead transfers the resin to a secondary injection cylinder and ram (8).

Extrusion Injection

Several systems have been described in which ram action has been eliminated altogether, and the extruder is used directly to melt the resin and to inject melt into the mold. Several such systems have been built for filling multiple molds in sequence. One such operation is described in U. S. Patent #2,656,569 by A. S. Watkins et al.

The flow from the extruder is never stopped, but is valved to flow into a succession of molds in the series, while the previously-filled mold cools and discharges the molding and is reclosed for the next injection. Some bottle-blowing operations employ similar techniques (9).

In most other systems involving extrusion-injection, the flow from the extruder must be stopped for a part of the cycle. This intermittent flow may be accomplished in two ways; intermittent and interrupted extrusion. In intermittent extrusion, the screw is stopped between shots. In this operation, the ultimate plasticating capacity of the extruder is not realized since the machine operates only during the injection cycle.

In interrupted extrusion, the screw rotates continuously and the melt flow is interrupted usually by means of a valve (10). Special screw designs incorporating deep flights prevent the build-up of excessive heat and pressure while the flow is interrupted, and also permit unusually fast discharge of the melt during the injection cycle. In this way, interrupted extrusion makes it possible to eject shots at momentary extrusion rates far in excess of the normal rated capacity of the extruder.

Molding Operations

A variety of molding operations for use with modified extrusion operations already have been mentioned

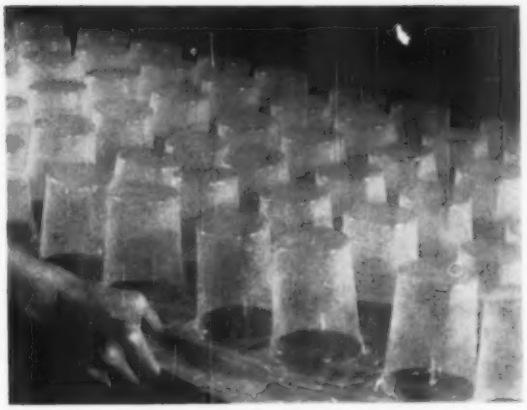
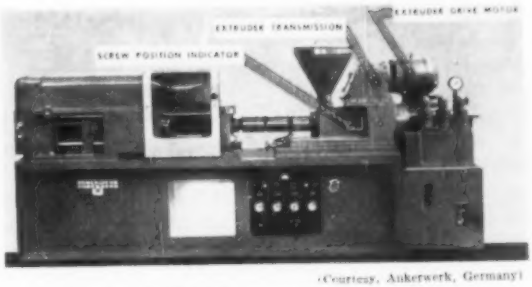
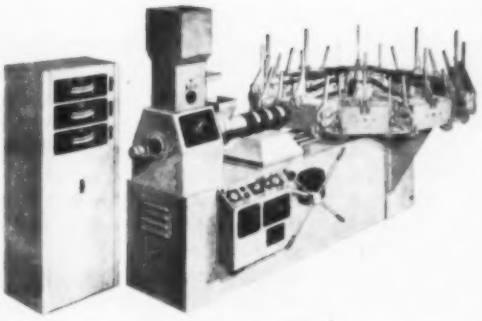


Fig. 2. Pint containers from extruded polyethylene sheet.



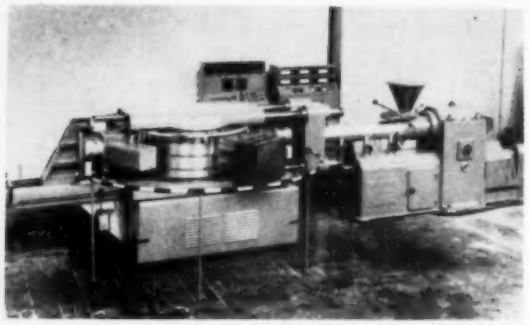
(Courtesy, Ankerwerk, Germany)

Fig. 3. Screw-type injection machine.



(Courtesy, International Vulcanizing Corp.)

Fig. 4. Foster-Wucher extrusion molding machine.



(Courtesy, Continental Machinery Co.)

Fig. 5. Extr-A-Formatic extrusion-molding machine.

in the previous paragraphs. It may, however, be helpful to review the principal systems which have been described.

The single mold and clamp system of essentially the same design as that used in standard injection machines has been used in a number of machines, e. g. the Jackson-Church, Reed-Prentice "Jet Flow", and most of the European reciprocating-screw machines.

Since extrusion plastication gives molding machines an unusually high melting capacity, it follows that production often will be limited by the rate at which the mold can cool and re-solidify the resin. The need for increasing this mold cooling capacity of extrusion-molding equipment has spurred the development of multiple-mold machines.

Multiple molds have been used in a variety of ways. In some instances, they have been mounted on stationary presses and connected to a central extruder through a valve and manifold system. Such a system is referred to in the patent by Watkins mentioned previously, and offers the advantage that full pressure can be applied throughout the cooling cycle.

In other cases, multiple injection molds have been mounted around the periphery of a turret (6) as in the Foster-Wucher (11) (see Figure 4) and Troester machines (12) (see Figure 5). One turret-type machine using compression molds has been built for our laboratory to permit us to mold metered slugs from an interrupted-extrusion system. Most of these turrets operate at low mold pressures, or apply high pressure only during part of the cooling cycle.

Future Outlook

This paper does not intend to predict the immediate demise of the conventional injection molding cylinder. However, the important advantages inherent in screw plastication make it certain that increased attention will have to be devoted to extrusion-molding operations as defined in this paper. In particular, the benefits of better melt temperature uniformity attainable in screw plastication will make it possible to control and reduce molded-in stresses in finished parts and, thus, will permit molding to closer tolerances. Wide areas for the application of those polymers which have a narrow processing range between the melting temperature and the decomposition temperature can open up through the use of these processing improvements.

At the present time, it is difficult to predict which particular combination of plasticating and molding techniques gives the greatest promise for the future. The choice of an optimum plasticating and molding device will have to be based on the requirements of the particular molding operation. A break-down of molding operations into segments or categories of shot size, tolerance, shape (area-to-volume ratio), number of items required, etc., combined with detailed engineering analyses and cost studies of the various machine systems discussed here will permit a rational selection of the best combination of machine components for various production requirements.

Because of the wide differences in these requirements, it seems certain that several types of extrusion molding machines will gain acceptance, each of which will have advantages in particular segments of the industry. We can expect that these machines will contribute to raise the quality standards for molded products and the productivity of molding processes.

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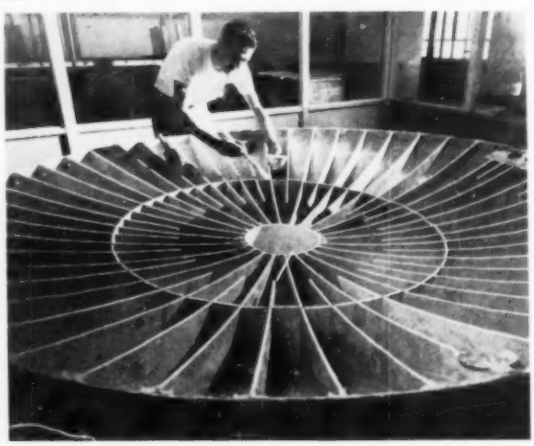


The new "Seeing Eye" for Tartar missiles on Navy ships is a giant reinforced-plastic radar reflector assembled by Republic.

(*left*)
G. A. CLARK, *Asst. Supt., Plastics Production Dept.,*
and (*right*)
C. B. HAVENS, *Group Leader, Polychemicals Research Dept., The Dow Chemical Co., Midland, Mich.*

Stabilization of Linear Polyethylene Against Ultra-Violet Light

Combinations of antioxidants and ultra-violet light absorbers are shown to provide effective stability to outdoor exposure.

THE advent of linear polyethylene with its unique physical properties vitalized interest in its use in monofilament fibers, both indoors and outdoors. Experiments involving the melt extrusion of this new polymer into 10-mil monofilaments were carried out to determine the proper orientation temperatures and stretch ratios.

The monofilaments were produced by extrusion from conventional saran extruders, followed by stretching 7-10 fold at 100-125° C. These filaments possessed tensile strengths in the range of 50,000-100,000 psi., and exhibited slightly lower knot strengths. These filaments could be pigmented and extruded into a variety of colors, and all indications pointed toward potential outdoor fabric markets. The problem of outdoor stability remained to be solved.

Preliminary experiments demonstrated that linear polyethylene is not unique in its outdoor aging resistance. Samples with original knot strengths of 50,000 psi. were exposed for seven days under RS-1 sunlamps and became so brittle that a knot could not be tied in the filament without breaking it.

The sensitivity of the more highly branched high-pressure polyethylene to photo-oxidation is well known. The only commercial outdoor formulations which we were aware of at that time, employed two percent of a carbon black with 0.1-0.3% of a commercially-available antioxidant. However, such formulations restrict one to the color of black, so a search for useful additives was initiated. The goal of this search was to provide a stable monofilament formulation which could be extruded into a variety of colors.

Experimental Procedures

The linear polyethylene used was a 0.5 melt-index resin produced by the Ziegler process using $TiCl_4$ and an aluminum alkyl. The resin was in powder form, and the additives to be evaluated were dissolved in a volatile solvent and incorporated into the resin. The formulated resins were extruded at 200-220° C., quenched in boiling water, and stretched 7-10 fold while in the boiling-water bath. Tensile strengths of the 0.010-inch diameter filaments thus produced ranged from about 50,000 to 80,000 psi. Filaments were wound on polystyrene cards for all exposure tests.

SUNLAMP AGING. Exposure cards were placed on a turntable seven inches below two G.E. RS-1 sunlamps. Ambient temperatures ranged from 40-50° C.

FADEOMETER AGING. Exposure cards were placed in standard fadeometer racks.

Based on a paper presented originally before the ACS Division of Paint, Plastics, and Printing Ink Chemistry meeting in Boston, Mass., on April 5, 1959.

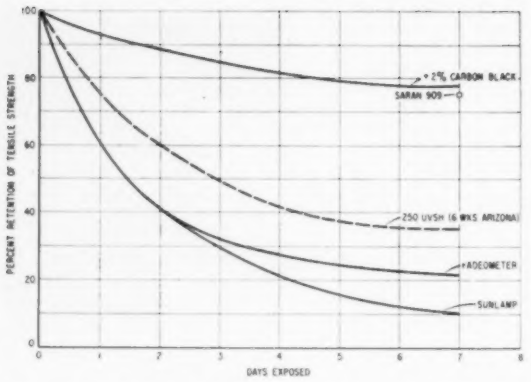


Fig. 1. Aging curves for linear polyethylene monofilaments.

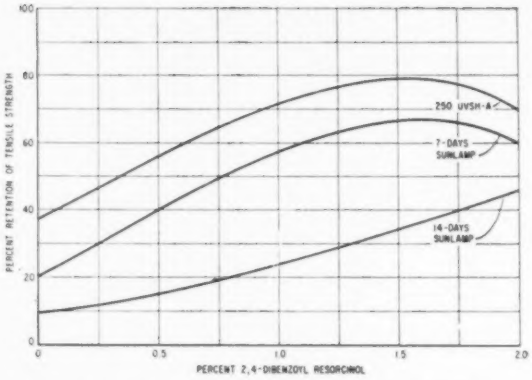


Fig. 2. Effect of dibenzoyl resorcinol on light stability.

ARIZONA AGING. Exposure cards were mounted at a 45° angle facing south at the Desert Sunshine Exposure Station, Phoenix, Arizona.

STRENGTH TESTS. All measurements were made using a Scott IP-4 inclined-plane tester. Results reported for tensile strengths are averages of five or more checks. In many cases, 10 checks were made.

OXYGEN UPTAKE STUDIES. Molded disc samples were placed in a closed system which was maintained at 150° C. and 760-mm. pressure. Pure oxygen was allowed to flow around the sample at a rate of 500 ml. per minute (CO, CO_2, and H_2O were removed continuously). The uptake of oxygen was measured volumetrically, and the change in volume was plotted against time of exposure.

After the induction period, a steady-state absorption rate is established. Extrapolation to zero absortion shows the induction time (hours), and the slope shows the absorption rate. The induction period was used as an index of efficiency of the antioxidant which was formulated into the polyethylene sample.

Results & Discussion

Figure 1 shows typical aging curves for linear polyethylene. No noticeable color change of the base resin was found after exposure to ultra-violet light, but the polymer experienced serious molecular breakdown as was evidenced by loss in tensile strength. This property was used as a measure of degradation throughout our experiments. Exposure times under various sources of ultra-violet light were plotted against the percent retention of tensile strength.

The dotted line in Figure 1 represents the aging of a linear polyethylene monofilament exposed to direct sunlight in Arizona. The time of exposure is measured in ultra-violet light hours. The small square represents the percent retention of a typical outdoor saran filament after seven-days sunlamp exposure. Sunlamps were used primarily for accelerated testing because a large number of samples could be exposed in a given time and space, and results correlated well with outdoor exposures.

Photo-oxidation is initiated by the removal of a proton from a peroxide group on the polymer chain, or at some weak point along the chain, forming peroxide or hydrocarbon free radicals. The production of free radicals is propagated by free radical attack at receptive or weak points along the chain, forming additional radicals, or by reacting with molecular oxygen to form additional peroxide free radicals.

In the termination step, free radicals are deactivated through various coupling reactions. It is believed that chain scission and cross-linking occur through disproportionation of peroxide free radicals.

Chain scission can be retarded by the use of antioxidants which enter and accelerate the termination step, reacting with the free radicals and, in most cases, forming inactive products.

A great deal of work has been reported on the use of anti-oxidants. Useful types of antioxidants include phenols, bisphenols, salts of phenols, salts of amines, thioethers, amines, and selenides. Many of these compounds, while being effective as antioxidants, do impart color changes either during extrusion or after exposure to ultra-violet light. Examples of this change are uninhibited phenols which undergo oxidation to colored quinone-type products.

Several hundreds of antioxidants and proposed antioxidants were tested as to their efficiency in retarding the photo-oxidation of linear polyethylene. Formulated samples were extruded into monofilament, and exposed under G.E. RS-1 sunlamps and outdoors in Arizona. After certain exposure periods, the specimens were graded as to color, and tensile strengths were determined and compared to the tensile strengths of corresponding unexposed filaments.

The classes are arranged in order of decreasing effectiveness. The substituted p-phenylene diamines were very effective antioxidants, but imparted severe color changes to the extruded filaments. The substituted 4,4'-bisphenols also are quite effective, and have the advantage of very little color introduction. The bisphenol sulfides and poly-phenol sulfides showed good effectiveness with little color introduction. The substituted phenols also show antioxidant activity, but many of them did introduce some color.

Because of the availability of a large class of substituted bisphenols, much of our antioxidant screening was done in this area. The data obtained with a variety of bisphenol compounds are classified in Table 1. Each group in Table 1 is arranged top to bottom in order of increasing efficiency. The percent retention of tensile strength (RTS) after seven days exposure under sun-

lamps also is shown. While it is well known that antioxidants may be rated quite differently when tested at widely different temperatures, and under the absence or presence of ultra-violet light, the data from the separate test procedures correlate quite well.

The data in Table 1 also show that the compound groups are lined up in order of increasing branching of the alkyl substituents *ortho* to the phenolic hydroxyl groups. In the 2,2'-bisphenol group, one can see that a highly branched substituent *para* to the phenolic group is not beneficial, whereas a methylene group in this position appears to enhance the activity.

The manner in which antioxidants retard chain scission by accelerating the termination step of the aging process has been discussed. It should be possible, with the aid of appropriate ultra-violet light absorbers, to retard degradation further by retarding the influence of light energy in the initiation step of the process.

In the area of ultra-violet light absorbers, we were fortunate in having had broad experience in the development of compounds and test procedures for other polymers, such as saran copolymers and polyvinyl chloride. The structural effects of a six-membered chelate bond formed through hydrogen bonding of phenolic hydrogen to ortho carbonyl groups, such as found in 2-hydroxy benzophenone, are well known.

The most effective light absorber we have found to date is 2,4-dibenzoyl resorcinol (Dow Light Absorber DBR), which seems to possess great resonance stability. Other effective compounds tested were 2,4,6-tribenzoyl resorcinol (TBR), salol, and 4'-tertiary butyl salol.

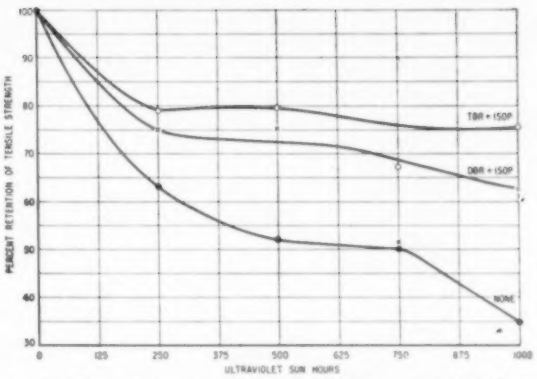


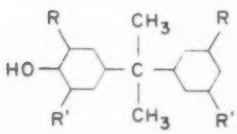
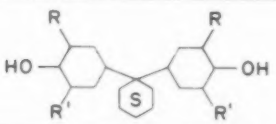
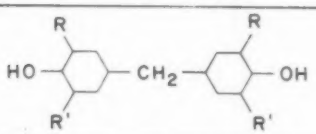
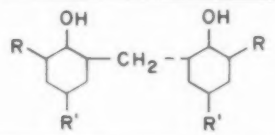
Fig. 3. Effect of direct weathering in Arizona on polyethylene monofilaments.

In Table 2, are shown the effects of two of these compounds upon the aging characteristics of polyethylene. Isop, the antioxidant used, is 4,4'-isopropylidene bis (2-tertiary butyl phenol). These ultra-violet light absorbers appear to have little or no effect on thermal oxidation, and seemingly do not enter into the free radical termination step.

The effect of increasing concentrations of Light Absorber DBR, upon the percent retention of tensile strength for monofilament samples exposed outdoors in Arizona and under sunlamps is shown in Figure 2.

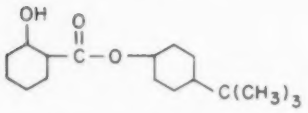
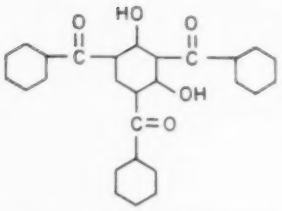
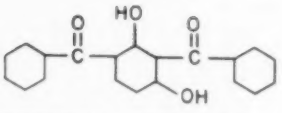
The third phase of this research involves the com-

Table 1. Effect of Structure on the Effectiveness of Bisphenols as Polyethylene Antioxidants (5% in Polyethylene).

STRUCTURE	R	R'	OXIDATION INDUCTION TIME-HOURS AT 150°C	PERCENT * RETENTION OF TENSILE STRENGTH
	CH_3	H	16.9	36
	i-PROPYL	H	20.8	40
	t-BUTYL	H	29.4	—
	H	H	7.2	—
	CH_3	H	19.2	36
	i-PROPYL	H	30.6	37
	H	H	2.3	<25
	c-HEXYL	c-HEXYL	23.2	35
	t-BUTYL	t-BUTYL	44.6	40
	H	H	6.1	<25
	t-BUTYL	t-BUTYL	9.8	34
	t-BUTYL	CH_3	23.8	37
	Br	Br	—	55

* AFTER 7 DAYS EXPOSURE TO AN RS-1 SUNLAMP

Table 2. Antioxidant Activity of Ultra-Violet Light Absorbers (1.5% in Polyethylene).

COMPOUND	OXIDATION INDUCTION TIME-HRS. AT 150°C	% RETENTION OF TENSILE STRENGTH (7 DAYS UNDER RS-1 SUNLAMPS)	ORIGINAL FIBER COLOR
 t-BUTYL SALOL	2.3	30	NATURAL
 TRIBENZOYL RESORCINOL	—	28	L. TAN
 DIBENZOYL RESORCINOL	2.8	47	YELLOW
BLANK	1.1	20	CLEAR

bination of effective antioxidants with effective ultra-violet light absorbers to obtain the stability required for the entry of polyethylene into outdoor uses.

Long-term Arizona outdoor exposure data, as represented in Figure 3, show the advantage of using a combination of antioxidant and ultra-violet light absorber over using antioxidant alone at an increased concentration. Point "x" on the figure represents the weight-equivalent of antioxidant alone compared to the combined weight of antioxidant and ultra-violet light absorber.

Conclusions

Linear polyethylene produced by the Ziegler Process has shown promise as a melt-spun fiber. Unstabilized monofilaments exhibited loss of physical properties such as tensile strength when exposed to ultra-violet light.

Degradation by photo-oxidation may be retarded by the addition of appropriate antioxidants or efficient ultra-violet light absorbers. Experiments involving oxygen up-take at 150° C. and exposure to ultra-violet light indicated that antioxidants and ultra-violet light absorbers affect separate phases of the photo-oxidation mechanism.

The effect of structure upon the efficiency of various bisphenol antioxidants to inhibit both thermal and ultra-violet light degradation is discussed. Results reported show that combinations of antioxidants and ultra-violet light absorbers in linear polyethylene provide effective stability to outdoor exposure.

—THE END

One of the new New York City buses with reinforced plastic seats, molded by Molded Fiber Glass Co., and employing Owens-Corning Fiberglas as the reinforcement.

Guest Editorial

HAROLD SCHOR, *Pres.*
Harold Schor Assoc.
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Publicity—An Obligation or a Sales Aid?

A recent "Guest Editorial" (October 1959, p. 41) in PLASTICS TECHNOLOGY deplored the so-called "secrecy" of many industrial firms. By their reluctance to reveal production details, (the editorial implied) these companies were losing good opportunities for publicity in the trade and technical press. And further, they have a "moral" obligation to disclose new manufacturing methods.

As a professional industrial publicist, the writer is in serious disagreement with these opinions, and feels that these attitudes act as a deterrent to executives who may be considering the initiation of an industrial or technical publicity program. Many of them fear publicity precisely because of strident pleas for "disclosure". To such executives, I want to make three major points:

(1). There are no "moral" issues or social obligations involved when deciding what type of information to release as part of an industrial or technical publicity program.

(2). Sound technical and industrial publicity programs do not depend on the revealing of production information. There is a very wide area of design and performance data suitable for the planning and writing of meaningful articles. Also, editors of responsible industrial publications realize the problems of management in respect to new developments, and are sympathetic when asked not to reveal specific details.

(3). When considering industrial publicity, the "scoop" and "hot copy" attitude should be viewed with extreme suspicion. These are throwbacks to press agentry, and hinder the development of a long-range program which would command the continued respect of publication editors, and pay off for the client in terms of real acceptance of his products or services.

Let's clear the air.

Whose "Morals"?

In our opinion, industrial firms do not owe it to the world to reveal new developments, and if they do announce such developments, it should not be for considerations of "fairness", but for sound business reasons.

The spirit of competition—economically and psychologically at the very heart of our social system—would be violated by indiscriminate revelation of production details. The company has spent good money—made a capital investment—in improving its products. It owns that improvement. Aren't the owners entitled to profit from the advanced technology that results from their investment?

Instead of viewing a company's unique and hard-won technical development lightly, the writer prefers to believe that most firms have a secret (without the quotes) when they claim they do. A new development is beneficial—improves performance, improves product quality, increases production rates, and reduces costs—precisely because it is unique. Otherwise, there would be no "secret."

On the "moral" issue, isn't the company performing a genuine service by making available to industry products and services which are the result of painstaking research and development? And, by providing articles which explain how to design with (or for) the new material, method or component, it is giving the user an additional service.

Sound Publicity

Why should an industrial firm engage in a technical publicity program—what's in it for them?

Regardless of the promotion technique used—space advertising, direct mail, trade show exhibits, or publicity

—it must be an effective sales aid. There is nothing sacred about publicity that allows it to evade this cardinal rule. While the reasons for embarking on a public relations campaign may be only indirectly related to selling, as in the case of building a "corporate image", publicity programs should have specific sales goals. Like any other service, it must pay off.

Technical publicity was developed in the post-war years as a much-needed adjunct to the established techniques of space advertising, direct mail and corporate public relations. As in space advertising, the function of technical publicity is to bring a specific message about a service, product, or material from the manufacturer or supplier to the potential customer, usually by way of appropriate printed media. However, publicity differs from advertising in that the donor does not control the final form of his message; worthwhile publications reserve the right to present editorial material in their own way—to fit the needs of their readers.

Technical publicity is a method of putting a company's technical story in the various industrial, technical, and business publications which represent segments of the total market. When executed by an experienced technical publicist, this becomes a planned series of informational stories and feature articles.

For producers of engineering materials and components and related services, the backbone of a good publicity program is a continuous flow of stories describing the engineering properties of these materials and components, and explaining how the user can design with them. Such stories should include some details of the "workability" of the material, especially if it is to be sold in "raw" form such as a molding powder, or in semi-finished form such as sheets, rods, tubes, and the like. However, this aspect is really a description of the material's ability to be fabricated, rather than a detailed "how-to-do-it" guide. Where it is possible for the manufacturer to reveal production details, the technical publicist will develop special fabricating stories . . . but only as part of the over-all, integrated publicity program.

Can a full-fledged publicity program operate effectively without divulging "inside" production information? Let's see.

One of our clients is a well-known producer of tiny engineered parts—both molded plastics and die castings. These intricate components are produced by automatic techniques in specially-designed machines—and emerge in finished form in a single operation. Top management of this company feels it has the "jump" on competitors, and it has upheld an inflexible policy not to reveal specific details of this technique.

Has this company disqualified itself as an important source of information for the technical press? Far from it—a veritable flood of feature articles, short features, "data stories", picture-caption stories, etc., on products made by the company's techniques has been published. This, despite the fact our client has received a barrage of requests to reveal the design of its machines, molds and dies, as well as details of the technique itself.

A specific example might furnish some answers. We recently learned about a well-known electrical manufacturer who redesigned a switch component from a three-part assembly to a single part, thereby reducing costs and improving performance. They did this by utilizing our client's unique facilities, and by designing the new component so that it could be produced by these automatic methods. We gathered a great deal of comparative design and performance data from the customers' engineers. When we offered this story to the editor of an electronics publication, he asked "How is it done?", and we replied "Our client won't tell". Acting under the code of "we must know everything", the editor seemed quite unhappy. However, after studying our material—which was of genuine value of his readers—he not only accepted the article, but gave it feature treatment. Incidentally, the same "pool" of information was the source of separate (and completely different) feature articles for an electrical and a design engineering publication.

Beware Unsound Approaches

Unfortunately, there are still vestigial remnants of press agentry in the field of technical publicity. The tradition built up by the Broadway and Hollywood "publicist" is based on the assumption that only sensational developments qualify for the printed page. This, of course, is true for newspapers and other mass-circulation periodicals. But to reach the engineer or technical specialist—the prime function of technical publicity—the ideal media are the hosts of industrial and technical publications, both horizontal and vertical, which serve their special reader groups consistently and well.

It would seem that the difference between the two approaches is crystal-clear. Yet, many industrial executives have the idea (or have been led to believe) that the only way to "crash into print" is to reveal something that has never been discussed anywhere previously. If we apply the principle of reductio ad absurdum to this conception, then all industrial publishing should cease immediately, since most developments are based on previously-discovered scientific principles.

The truth about good technical or industrial publicity is simple, like all truths. Practically every industrial firm has a story to tell, and many industrial and business publications are interested in this story provided that it is factual and useful to their readers. These publications could not fill their pages month-after-month or week-after-week without reliable sources of information. If they depended on the "stop-the-press" development or the contrived gimmick, they would quickly run out of material and—more important—they would no longer provide a valuable service to their readers.

The only sound industrial publicity approach is (1). careful analysis of the company's marketing problem; (2). taking stock of what type of information the company has to offer; and (3). deciding how to utilize this information to meet the company's objectives in a manner that will be useful and acceptable to publication editors. This calls for imagination . . . and lots of hard, plodding work. But it's the only approach that's consistently effective.

—The End

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Evaluating Plastics for Compression Molding of Phonograph Records

How a capillary extrusion rheometer can be used to evaluate plastic materials and molding cycles

FLOW is one of the most important properties of a plastic intended for use in the manufacture of phonograph records. The growing popularity of "high fidelity," and the accompanying improvement of record players, has stressed the importance of quality molding and the exact reproduction of the original lacquer recording.

Records are being molded today with as many as 350 grooves per inch. A record groove is V-shaped (90° angle) with dimensions of 0.0023- and 0.0012-inch for the width and depth, respectively (1).* The land between the grooves may vary from 1-4 mils in thickness. The biggest single problem during the record molding operation is to make plastic flow into the microscopic grooves of the stamper.

One criterion for determining the suitability of a plastic for records is the percentage of defective records molded. Some rejects are caused by non-fills, blisters, or warpage—all of which are related to flow. A second factor, also dependent on flow properties, is the weight or thickness ot a record molded under standard conditions.

Flow Properties

A record press cycle, which consists of compression, heating, and cooling under pressure, will last anywhere from 25-60 seconds, depending on the type of record molded and the plastic being used. In order to obtain an acceptable record, a delicate balance between the various cycle phases and the rheological properties of the plastic must be achieved.

Simple flow tests may be used to measure the rheological properties of the plastic material. These tests may be intended to screen new compounds, and/or be used for day-to-day control purposes. In order that the data be meaningful, the test conditions must be identical to, or capable of being correlated with the actual end-use fabrication. The parameters considered important not only in compression molding, but also in extrusion and injection molding, are temperature, shear rate, and shear stress. Shear rate is indicative of the speed at which the plastic is being deformed, while shear stress indicates the pressure employed. The absolute values of each of these quantities depend on the process being considered.

The viscosity dependency on temperature and/or shear rate does differ from one material to another. Small changes in molecular weight or even formulation may have marked effects on the viscosity curve.

* Numbers in parentheses refer to Bibliography at end of article.

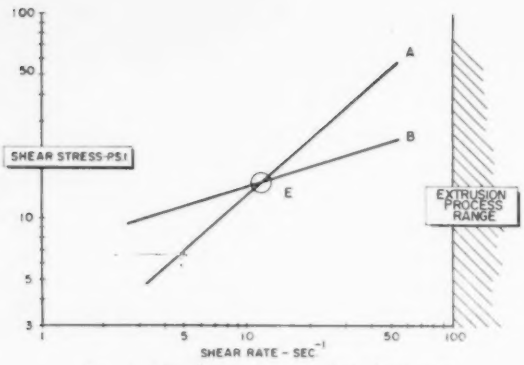

Fig. 1. Log shear stress vs. log shear rate.

It is important, therefore, that the plastic be tested at the same temperaures and range of shear rates that prevail during the manufacture of records.

Measurements made at a single set of conditions (i.e., at a given temperature and shear rate), may result in drawing erroneous conclusions with respect to the viscosity of the plastic at other conditions. Figure 1 shows the log shear stress plotted against log shear rate for the two materials, A and B. Tests made at a single shear rate, as at Point "E", would indicate that A and B were identical. If the process was operated at any shear rate other than "E", the two plastics would behave quite differently. The shaded area to the right in this Figure indicates the region in which most extrusion processes operate.

Insofar as we have been able to ascertain, no one has ever determined the range of shear rates in a commercial phonograph record press prior to our work. This study was undertaken to enable us to pick the testing conditions that would be the most representative for the process. Temperatures are relatively easy to measure, but unfortunately there are no formulas developed for determining the shear rate in a phonograph record press. The record press, however, is very similar in operation to the parallel-plate plastometer, a standard ASTM test. The latter instrument measures the flow properties of a material by compressing it between two steel plates at a constant load and temperature. This is essentially the same thing that takes place in a record press, except that the plastic is cooled during the latter stages of the cycle.

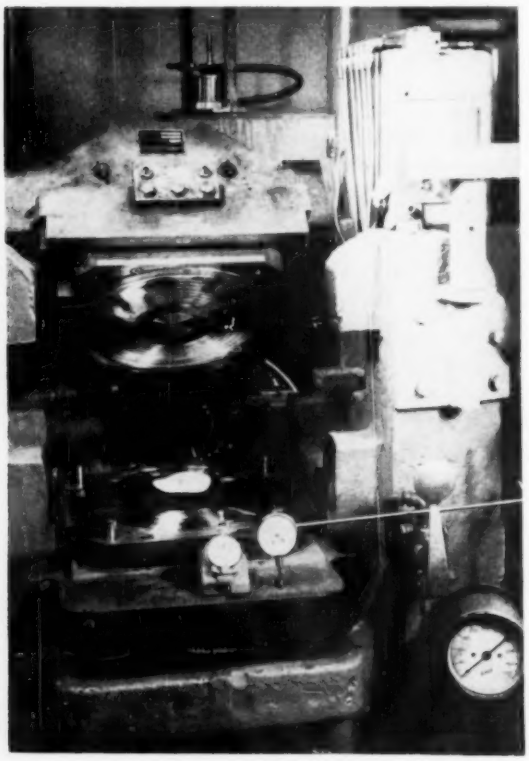

Fig. 2. Record press with biscuit ready to be molded.

Experimental Results

Dillon and Johnson developed a formula for calculating the average shear rate in a parallel plate plastometer (2). In order to use this equation, a plot of the distance between the record press platens as a function of time had to be obtained. Figure 2 shows the record press with a biscuit ready to be molded. In Figure 3, the cycle has begun and shows the distance between the platens being measured by a dial micrometer (right foreground) while a stop watch (left foreground) shows the time. The pressure gauge (right) indicates the hydraulic pressure on the 12-inch ram at any time during the cycle. Motion pictures were taken of the press during a number of cycles. Thus, the rate of mold closing for each cycle was recorded permanently and could be determined accurately at a later date.

Data was read from the films by use of a microfilm viewer, and used to obtain the curves shown in Figures 4 and 5 for vinyl and styrene biscuits, respectively. The solid lines indicate the distance between the platens, with Curves 1 and 2 in Figure 4 and Curves 3 and 4 in Figure 5 representing slow and fast closing rates, respectively. The dotted lines represent the pressure at any time during the cycle, and correspond in designation to the respective solid curves. The platens come into contact with the biscuit at the point shown by the arrow (about 375 mils in Figure 4). The relatively high viscosity of the vinyl compound at the molding temperatures causes the rate of closing to decrease quite significantly as the compound flows out between the platens.

There are four springs on the press which are compressed as the press closes, and which are responsible for dropping the ram quickly when the hydraulic pressure is reduced at the end of the cycle. This compression of the springs plus lifting the mass of the lower platen is responsible for the initial pressure reading on the gage. When the platens do make contact with the biscuit, the pressure increases gradually to a pre-set maximum that is reached at just about the time the plastic has filled the space between the two surfaces. The rate of closing depends on the volume of oil being pumped, and is independent of the pre-set maximum pressure attainable when it is set above 1,500 psi.

In comparing Figures 4 and 5, it should be noted that the styrene causes very little reduction in the closing rate until the cavity is filled, and the excess com-

pound is being forced to flow out between the retaining rings.

Since the total compression of the record biscuits took place in a time interval of 4-10 seconds, considerable care had to be exercised in taking data from the film. Small errors in reading either the stop watch or dial micrometer may greatly change the slope of the curve. This, in turn, will affect the calculated values for shear rate.

If the portions of the curves shown in Figures 4 and 5 during which the plastic was in contact with both the upper and lower platens are plotted on a logarithmic scale, we obtain curves of the type (3):

$$y = KX^n$$

where y is the distance between platens, X is time, and K and n are constants depending on the type of material being used and the press closing rate.

At the slow closing rate, both the vinyl and styrene compounds exhibit Bingham body characteristics; i.e., a finite stress has to be applied before flow will occur. At the faster closing rate, however, both materials approach Newtonian-type behavior. Most record press cycles do not operate at these faster closing rates since the plastic flows out too fast to obtain a good reproduction of the stamper under these conditions. The slope of the straight line portions of these curves are equal to n in the above equation.

The values for constants n and K, as well as the calcualted shear rates, are shown in Table 1 for each of the runs in Figures 4 and 5. Generally speaking, the record press operates over a shear rate range of approximately 0.05-1.0 reciprocal seconds.

The viscosity dependency on shear rate is less for vinyl than for styrene, as illustrated by the narrow range of shear rates for the vinyl compound. This would indicate that styrene is much more sensitive to changes in molding conditions than is vinyl. On our record press we have found this to be the case in that the mold closing speed and the heating and cooling portions of the cycle are much more critical for styrene.

The temperature of the plastic may be measured with a needle pyrometer, so we now have determined two of the three parameters (temperature and shear rate) necessary to define the rheological properties of a plastic for phonograph records. Shear stress, the third parameter, cannot be calculated directly. However, the apparent viscosity of a plastic is, by definition, the ratio of shear stress to shear rate at any given temperature. All that is necessary, therefore, is to obtain a correlation between performance of a plastic in record molding and the viscosity of this plastic in a rheometer measured under the range of shear rates mentioned above.

Table 1. Constants and Calculated Shear Rates.

Plastic Compound	Curve Number*	Constants n	K	Shear Rate at Three Seconds
Vinyl	1	—0.87	0.568	0.322 sec.—1
Vinyl	2	—0.54	0.325	0.815 sec.—1
Styrene	3	—1.38	1.62	0.063 sec.—1
Styrene	4	—0.95	0.318	1.010 sec.—1

* In Figures 4 and 5.

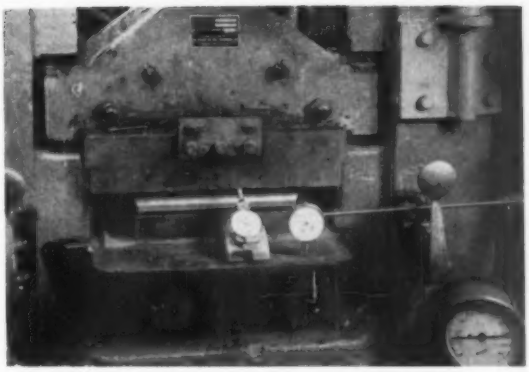

Fig. 3. Record press after molding cycle has begun.

A capillary extrusion rheometer is perhaps the best instrument to determine the flow properties of a plastic for phonograph records. It is possible to measure small differences between polymers, and both sample preparation and sample testing can be accomplished in a relatively short time. The parallel plate plastometer, on the other hand, requires elaborate sample preparation, is cumbersome in operation, and the experimental error frequently is larger than the differences in polymers being tested.

There is one other factor not previously mentioned which should now be considered, and that is the elastic properties of a plastic. It has been shown that the flow of a polymer is the sum of the elastic and viscous de-

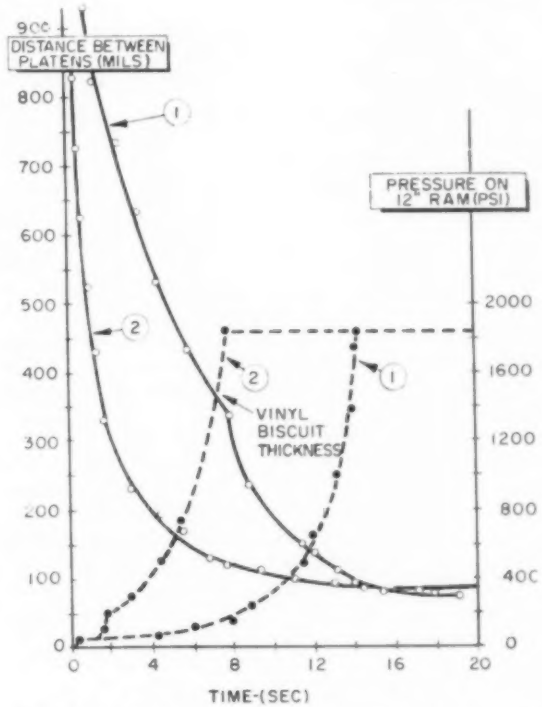

Fig. 4. Press closing rate and pressure curves for vinyl biscuit.

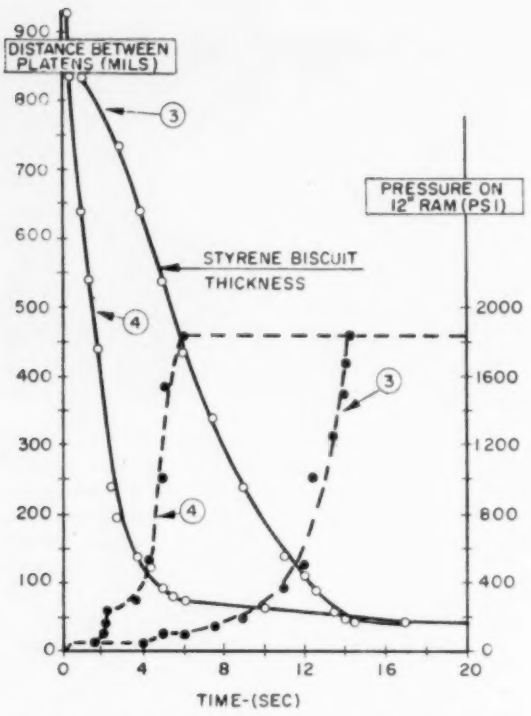

Fig. 5. Press closing rate and pressure curves for styrene biscuit.

formations (4). A proper balance of these two constituents of flow must be achieved in any test intended to be correlated with a particular process. On a capillary extrusion rheometer, this balance may be obtained by varying the length:diameter ratio of the capillary (5).

In our laboratory, we have obtained an excellent correlation between record molding behavior and the polymer's apparent viscosity measured with a capillary extrusion rheometer. Under our test conditions, we cover a shear rate range of 0.5-2.4 reciprocal seconds which corresponds to an apparent viscosity range of 5.6-1.1 pound-seconds per square inch. The capillary length:diameter ratio is approximately four. Optimum record molding behavior for a vinyl chloride-vinyl acetate copolymer is obtained when the apparent viscosity ranges from 1.2-1.7 pound-seconds per square inch.

This same approach can and is being used to study various plastics for either extrusion or injection molding applications. For these processes, however, the range of shear rates would be several decades higher than in compression molding.

Conclusions

If a polymer is to be tested to determine its processing characteristics in a particular operation, the test conditions must be identical or analogous to those of the process. We have discussed a technique for determining the important rheological parameters in phonograph record molding. To our knowledge, this is the first time that such an analysis of conditions during the record-molding operation has been undertaken.

This has enabled us to select an instrument that will best measure the flow properties of a plastic over the range of temperatures and shear rates existing in a record press. The control and/or screening of compounds by a test based upon these parameters will assure success in molding a record that meets the exacting specifications required by most record manufacturers.

Acknowledgment

The author would like to take this opportunity to thank Dr. E. H. Merz for his contributions and suggestions during the preparation of this paper.

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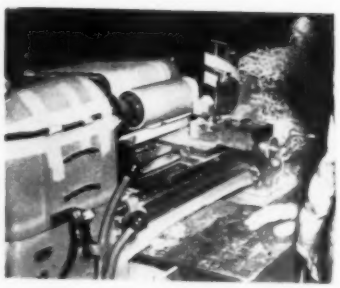

Lathe starting its transverse in turning OD to desired concentricity.

Better Textile Bobbins—Faster and Cheaper

Taylor Fibre Co., Norristown, Pa., has devised a method for cutting costs and simplifying operations in finishing tubular parts such as textile bobbins. A standard lathe is fitted with a home-built belt sander and with relatively simple controls for automatic sequencing. The set-up doubled bobbin production and freed a second lathe formerly required in sanding, while giving a more uniform finish.

The lathe-sander automatically faces the ends to specified length, parallels them, turns the outside diameter to narrow tolerances, and sands. Use of an expanding mandrel allows for variations in the tube length and diameter within limits of lathe size. The bobbins themselves were Grade XX paper-base phenolic tubing.

—THE END

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Nondestructive Quality-Control Tests on Finished Reinforced-Plastic Parts

How quality-control can be based on observing creep or relaxation of parts heated slightly above the glass point when lightly stressed.

IN 1954, a system of reinforced-plastics evaluation was developed which did not take samples to failure, but rather examined their characteristics under constant stress at elevated temperature (1)*. Because appreciable flexural stresses can be developed with hand-held, dead-weight loads; this system was attractive for on-the-job test setups for quality control purposes. Such a system was developed and placed in operation in October, 1955. In the course of this work, it was noted in many cases that specimens were apparently undamaged by the test cycle. This suggested the potential development of this method as a means of examining finished parts nondestructively.

By 1957, the nature of the effects being studied was understood much better and correlated with general polymer physics theory (2). By this time, confidence was accumulating to the point of attempting acceptance testing of finished parts and, about this time, two applications appeared which lent themselves to this approach. Even so, the experience in finished part testing is quite limited, although there is three years of production experience using a similar method on expendable specimens.

This paper reviews the previously-published principles on which the tests are based, gives a number of practical details helpful in setting up such procedures, and cites the actual shop experience in three case histories.

Scope

A nondestructive test on structural parts implies that some physical effect can be measured upon which strength depends, but the measurement itself imposes no damaging stress on the part. In other words, what is sought is an indirect measure of strength. It is the intent of this paper to show that certain phenomena of polymer physics may be interpreted for such a purpose. Since these effects involve only minor changes in resin state, "nondestructive" will be used to denote the approach described.

Any approach towards the determination of quality must first clearly state what is meant by quality.

* Numbers in parentheses refer to Bibliography at end of article.

Accordingly, the assumptions and basic premises on which this work rests are now stated thus:

ASSUMPTION #1. When reinforced plastics are molded of a liquid resin polymerized "in situ," the quality of the final part is directly related to the extent and character of such polymerization or "cure." Faulty cure may arise from mistakes in resin formulation, deteriorated curing agents, insufficient mixing, improper mold cycles, etc. In the thermosetting resin systems that we use, improper cure is defined in chemical terms by saying the cross-linking reactions between resin molecules have not gone sufficiently to completion.

ASSUMPTION #2. In a reinforced-plastic part, the stress in the complete member is divided between the reinforcement itself and the resin matrix which surrounds the strands of reinforcement. It is assumed that the designer has specified his reinforcement so that the resin will not be unduly stressed. If his specification is not observed and the reinforcement is improperly applied, the effect will be to throw additional stress on the resin.

ASSUMPTION #3. It is proposed, therefore, that a determination of cure deficiency coupled with the detection of undue stress in the resin matrix will pinpoint two highly significant factors governing the strength of the final part. The foregoing shall be accomplished at low stress levels. It is noted that no absolute determination of cross-linking or resin stress is involved. What is measured are departures in these properties from standards established by more conventional means.

Basic Theory

Increasingly it is understood that many resins used in reinforced plastics lose their brittle, glassy characteristic when heated; and behave, instead, like short, dead cheesy rubbers. Heating to higher temperatures will superimpose actual plastic behavior on these rubbery properties. The change between glassy and rubbery behavior takes place over a rather narrow temperature band. The temperature at which this transition takes place in any given polymer system is highly dependent on the chemical nature of the polymer and its degree of cross-linking. The validity of this observation governs the success of the entire approach.

In practice, the temperature at which glassy properties are lost and rubbery properties begin is determined on material of acceptable quality, and this is established as the test temperature. On material deficient in cure, the glassy properties are lost at a lower temperature so that well-defined rubbery and/or plastic properties now are observed at the test temperature. The development of excessive rubbery or plastic behavior under conditions where this does not occur in normal material is made cause for rejection.

It has also been shown that the observed temperature at which glassy properties are lost and plastic properties begin is not fixed for a given resin, but depends on the stress level of the experiment (2). Material under high stress shows a lower transition temperature than does material under low stress. The use of a reinforcement less efficient than that specified will throw proportionally more stress on the resin and, hence, will cause the development of rubbery properties at a lower temperature than is observed for normal material. The result of a deficiency in reinforcement is the same as a deficiency of cure—excessive rubbery and plastic effects at a temperature where such normally do not occur. The key to this method of inspection lies in means to detect rubbery and plastic properties in finished parts. How this may be accomplished will be better appreciated by a study of these states of matter.

The glassy state is considered to be normal for reinforced plastics. The material rings when struck, the deflection and recovery when loaded and unloaded sensibly are instantaneous. The elastic modulus of a laminate with the resin in the glassy state shows very slight temperature dependence. Under constant load, the creep is very small. When strained to some fixed strain, the force to maintain this strain does not decay but remains sensibly constant. In general, laminates tested with resin in the glassy state show classical elastic properties, see Figure 1 (Upper).

Resins in the rubbery state have lower elastic moduli and, hence, the deflection at constant stress will increase as the material passes from the glassy to the rubbery state. The response to stress no longer is instantaneous, and appreciable time (often in the order of minutes) will be required to reach equilibrium. As

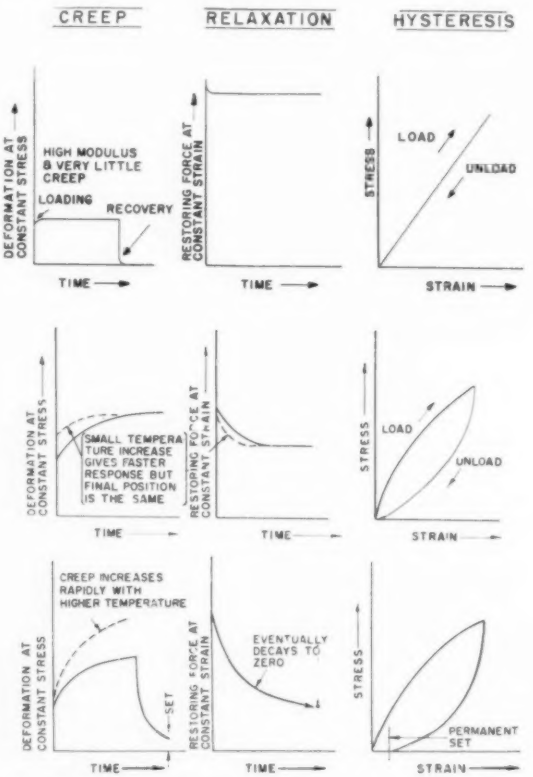

Fig. 1. Creep, relaxation, and hysteresis characteristics of reinforced plastics with the resin in the normal or glassy state (Upper); with the resin in the rubbery state (Center); and when the resin shows plastic action superimposed on rubbery elasticity (Lower).

the temperature is increased, the time to reach equilibrium becomes shorter, but the equilibrium position is unchanged (in an ideal rubber, the modulus increases with temperature, but our materials are far from ideal rubbers). Upon unloading, the material slowly recovers completely. When rapidly taken to some fixed extension and held, the load to hold this fixed extension decays rapidly to a constant value. Load-unload cycles show large hysteresis loops, but the sample shows recovery, see Figure 1 (Center).

Plastic behavior superimposed on rubbery behavior shows the characteristics of rubbery behavior. In addition, a specimen under constant load never reaches an equilibrium position, but continues to creep indefinitely. The creep rate is a decided function of temperature, increasing rapidly at higher temperatures. When deformed to a fixed strain and held, the restoring force decays asymptotically to zero. Upon unloading, permanent set is observed, which increases as the time of loading is increased, see Figure 1 (Lower).

The temperature range at which rubbery behavior is observed depends upon the stress level of the experiment. At high stress levels, it often is difficult to demonstrate rubberyness because the behavior is dominated by plastic action once the glass point is reached. As the stress level is reduced, the material shows an increasing temperature range of recoverable rubbery elasticity before plastic action dominates the experiment. The terms "high stress" and "low stress" are highly relative. For highly cross-linked resins, high stress refers to an appreciable fraction of the room-temperature rupture stress, but for poorly cross-linked materials, rubbery behavior is not disclosed until the stress is only a few percent of the room temperature failure stress.

The subject of anelastic response to stress is treated under the branch of science known as rheology, and mathematical expressions have been derived to predict the behavior of many rheological systems. For our purposes, it is not necessary to characterize rheology quantitatively, but only to recognize it if it appears. The proposed testing system adjusts experimental conditions so that normal material is on the threshold of rheological behavior. Well-defined rheology then is made the cause for rejection.

General Method

In order to set up a system of quality control based on detection of a change of state in the resin, it first will be necessary to accumulate a number of parts of known high quality and, if possible, other parts containing intentional defects. These parts then are lightly stressed for short periods of time at a number of ascending constant temperatures. After the piece is at each temperature, low constant stress is applied rapidly and either the creep or relaxation measured for several minutes. These experiments may be made repeatedly on the same specimen. Advancing the temperature in 10-15° C. increments, typical behavior will show hardly-perceptible creep or relaxation from room temperature to 60-110° C. At some temperature in this latter range, the creep or relaxation will be seen to increase rather sharply and show only a slight increase for the next

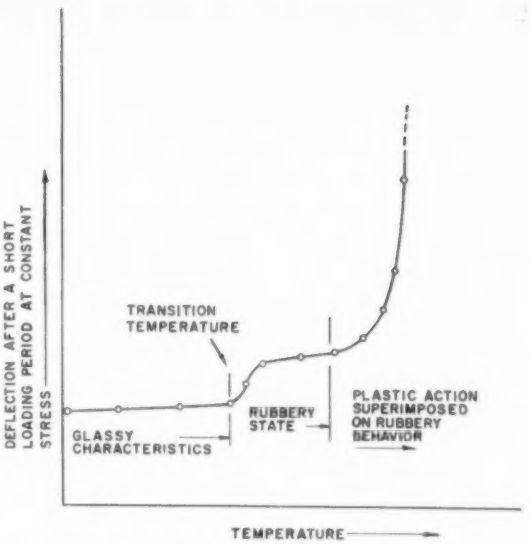

Fig. 2. Typical behavior when the same specimen is loaded successively at a low stress level with a number of constant temperatures.

10-20° C. thereafter. Further increases in temperature will show steadily increasing creep or relaxation until the specimen fails on loading.

The data then should be inspected to estimate a time of loading when the short-time creep typical of rubbery behavior has leveled off. This time interval, usually between one and three minutes, then is standardized for future experiments. The deflection vs. time data taken at a number of constant temperatures then is cross-plotted to show deflection at the standard time as a function of temperature. When this is done,

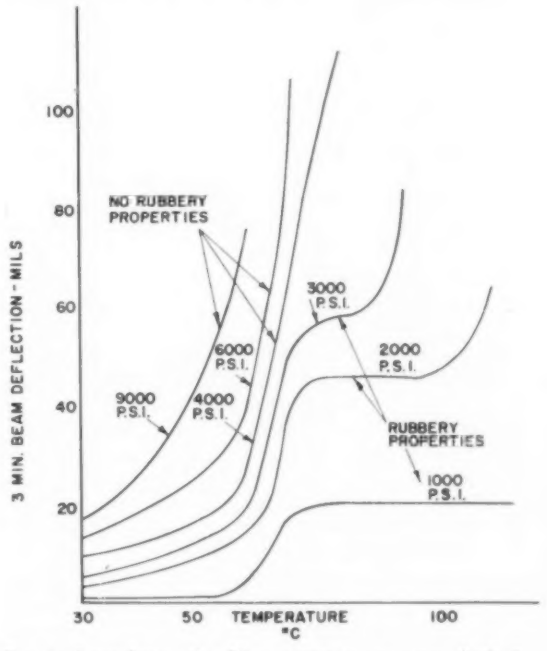

Fig. 3. Dependence of rubber properties on stress (25° C. rupture strength of laminate at 35,000 psi.).

the results should resemble the hypothetical example shown in Figure 2.

It may be possible that the plateau corresponding to the rubbery state will not appear when this is done. As previously explained, too high a stress level will obscure rubbery behavior so that only glassy and plastic properties will show. An example of this is shown in Figure 3 for the behavior of an epoxy resin designed to be quite flexible at elevated temperature.

Temperature-stress combinations to yield rubbery properties are unique for each resin-glass system, and must be determined by trial. Once this is done, the recommended temperature of test is slightly below the point where rubbery properties merge with plastic action. Minor variations in test temperature then will have a small effect on the results. While we have not made the attempt, it also is possible to set the temperature of test at the threshold of rubbery properties. Inferior material then brings the specimen into the rubbery range, which is a little safer. There is a risk that if material enters the plastic range too far, it will be damaged by over-strain.

When inferior material is presented for test, the results will be shown as in Figure 4. The whole rheological pattern has shifted to the left, and the deflection read at the established test temperature will show a decided increase.

These experiments are repeated on a number of samples until the reproducibility of the manufacturing process is established. Running samples with intentional defects then will show the sensitivity of the test in picking up possible sources of trouble. When this information is weighed with the requirements of the part, a "pass" or "fall" control limit is set, as shown in the hypothetical example of Figure 4.

The foregoing description applies to use of the creep approach. Generally similar results will be obtained for the relaxation approach, except that percent relaxation will replace deflection on the ordinate of the curve sheets.

The principles of change-of-state quality control have been given, but those attempting it for the first time will have to solve a number of practical details, as listed below.

The choice between the creep approach and the relaxation approach is primarily one of convenience. The relative advantages and limitations are given as follows:

Creep experiments are recommended when the part may be loaded with dead weights or by means of internal pressure. This implies that parts which can be formed into simple beams, cantilever beams, or hollow shells will be tested most successfully. In many cases, it will be possible to use a machinist's scale or slide caliper attached to the part to measure deflection or deformation. For more sensitive measurements, dial indicators or remote-indication electric extensometers are useful. For parts of irregular shape, it is effective to make a reference mark on the part, and follow the movement with a cathetometer. The use of telescopes for observing instrumentation inside hot ovens is highly recommended. For example, the 25-power telescope in a surveyor's transit will read a few mils 10 feet away. Therefore, the creep method is useful when a

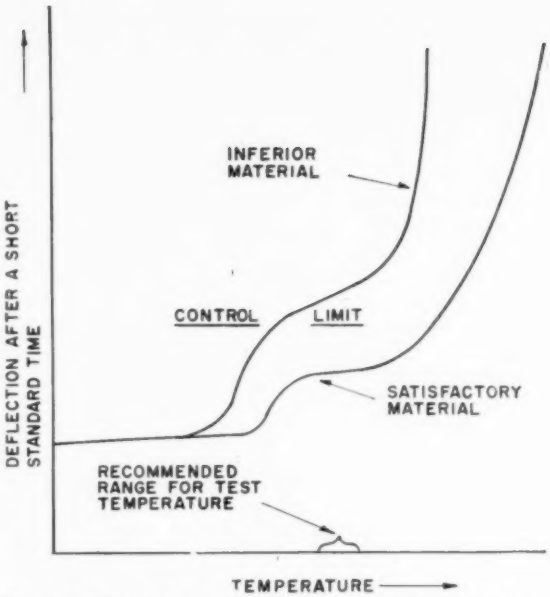

Fig. 4. Hypothetical example of expected test results comparing satisfactory and inferior material.

home-made loading method may be applied and the instrumentation required to measure strain or deflection is simple.

The relaxation approach is useful for parts that may be loaded conveniently in a testing machine. Since the loss of load is measured, no strain-measurement system on the specimen is necessary.

It will be noted that this simplified procedure is not a rigorous relaxation experiment. The initial strain attained by the specimen is constant only if modulus is the constant. This places a penalty on parts of lower modulus because the initial strain is higher and the test correspondingly more severe, and incidentally more searching. The risk is also higher that parts of marginal quality will be damaged by over-strain.

The limitation in the relaxation approach lies chiefly in the physical size of the part. The test must be made at elevated temperature, and this implies an oven that can be set up inside a testing machine. When allowances are made for the load bars which enter the oven to communicate force to the article being tested, the remaining space is somewhat restricted. It is obvious, therefore, that the relaxation approach only can be used on pieces of moderate size.

In either case, it is assumed that some significant mode of loading can be developed which does not create too formidable gripping or fixturing problems. Bending is more easily set-up for dead-weight loading, while some form of compression is simpler for a testing machine.

Good temperature control is important. This implies forced convection circulating-air ovens or constant-temperature control. With large parts, it is recommended that thermocouples be secured to the work so that it is known that the part in the oven, and not just the air, is at specified temperature. This requirement for good temperature control is the greatest drawback to this method of quality control.

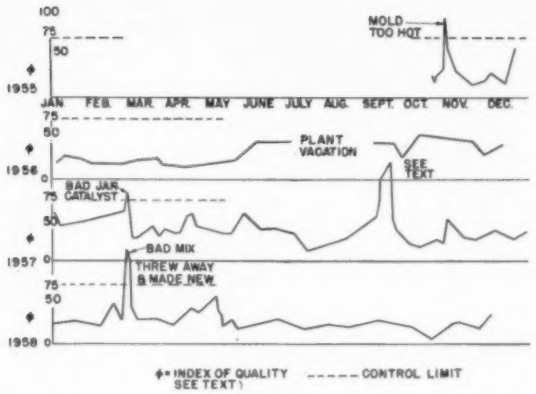

Fig. 5. Four-year quality control chart on change-of-state in corrugated members used as a spacer in large electric generator.

If the size of part will permit, hot circulating oil has definite advantages. The apparatus is simple, and can be improvised with kitchen ware on hot plates and simple thermostats. Deep-fat fryers have been pressed into service. It is not necessary to wait a long time after a specimen is made ready for the temperature to recover, as is the case in an air oven. Hot vacuum-pump oil as a heat-transfer medium does not seem to affect most reinforced plastics.

Compensation for variable part dimensions is an important consideration. The discussion up to this point has implied that only changes of state in the resin are important in obtaining deflection characteristics. It is well known that small dimensional changes, particularly in thickness, greatly affect response under load of any structural member.

Assuming that the part under consideration is amenable to conventional stress analysis, it is possible from load-deflection data to calculate the modulus of elasticity of the part in both the normal glassy state and in the rubbery state. If the modulus of rubbery elasticity, which is obtained from data taken hot, falls below the range determined as normal for parts of good quality, this is made cause for rejection.

A simpler but less rigorous method is to make two deflection measurements on the part; the first at room temperature, and the second at the specified test temperature. For pieces which otherwise are comparable, minor dimensional vibrations will raise or lower both readings approximately the same, so that the difference is sensibly constant. Deviations, therefore, are ascribed to some abnormality of the part. The practice of merely subtracting the initial room temperature deflection from the equilibrium deflection taken hot is recommended for shop inspectors who might have trouble with a more involved calculation.

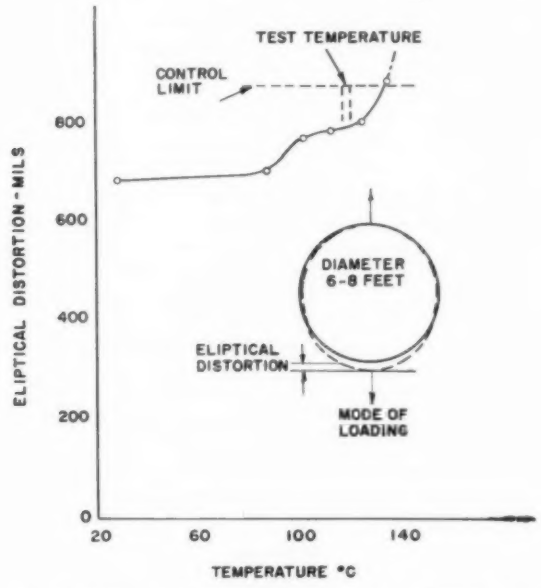

Fig. 6. Eliptical distortion of 72-inch diameter filament-wound hoop at 20,000 psi. maximum bending stress.

Case Histories

Having cited the general procedure for change-of-state testing, the experience obtained in actually using this method in three rather different applications will now be discussed. The first example was our pioneering endeavor and used expendable samples. From it and other work, specifications were established for nondestructive tests on a molded spring and on a large filament-wound hoop of heavy cross-section. These applications will be described in that order.

Corrugated Member

A radially-corrugated member molded from glass cloth is used as a spacer in a large electric generator. The original moldings were cut into appropriate segments, and this cutting operation was used to develop a test specimen from an extra corrugation. The specimen then was cut to be ½-inch wide, five inches long, and nominally 3/16-inch thick. It was loaded as a simple beam at approximately 6,000 psi. bending stress while being maintained at 125° C. To obtain an index of quality, we subtracted the room temperature deflection of the beam at the same stress from the deflection read after two minutes of loading at 125° C. This difference was designated by the index of quality (ϕ) which appears on Figure 5.

When the rough moldings are being cut to finished dimensions, the operator is instructed by the inspector to take certain pieces of trim selected at random, and make them up into test specimens. In addition, each batch of benzoyl peroxide-catalyzed resin is checked by taking a small swatch of the same fabric lay-up as used in the parts, and molding a test specimen which is tested before production can proceed. The test apparatus is located in the molding area, and it is possible to report a test within 10 minutes after the press opens. All resin, styrene, peroxide, etc., coming into the area also is tested for acceptance by the same method.

An inspection log has been kept on this test procedure, and from it a quality control chart has been plotted, see Figure 5. It will be noted that the process has remained under control with four exceptions when corrective action was necessary. Brief explanations ap-

pear on Figure 5, and are treated in more detail in the text.

In October 1955, difficulty with an instrument caused the mold to run too hot. Prior experience showed that such a condition resulted in a type of undercure which cannot be corrected by post baking the part (1). Restoring the mold to proper temperature corrected the difficulty.

At the end of February, 1957, a bad jar of paste peroxide catalyst turned up. Although its peroxide assay seemed normal, it gave inferior work. Discarding that lot of peroxide brought the process back to normal. In September, same year, word came that there was trouble in the molding area. Investigation showed that calibrated polyethylene pails were being used to measure resin by volume. These containers formerly had been calibrated to show the level of a known-weight of resin, but someone had been putting replacement containers alongside the last container used and had made the calibration mark with the aid of a practiced eye. No further comment is needed.

Again in February, 1958, an out-of-limit test is reported with a terse note in the log book, "bad batch, threw away and made new".

The general feeling is that degree of reproducibility has been very satisfactory, and that troubles have been nipped in the bud.

Coil Spring

A helical coil spring was machined from a glass-reinforced epoxy resin tube. Because of difficulties with the tube stock obtained from an outside supplier, two quality-control tests were needed. Stock was tested as received before machining out springs, and an acceptance test was run on finished springs. To check on the stock, an expendable, two-inch long specimen was cut off the tube as received from the supplier. The cylinder was loaded across its diameter, and the typical room-temperature failure load was found to be approximately 2,000 pounds. From this, 20% or 400 pounds was chosen for the relaxation test.

A small laboratory oven was set in the bed of the testing machine with holes cut through top and bottom for load bars. The holes for this purpose somewhat destroyed the former good temperature distribution of the oven. To improve the temperature control, a short length of three-inch diameter glass cylinder was epoxy bonded to the lower loading anvil so as to form a shallow cup which was filled with silicone oil to cover the sample. The oil derived heat from the rather massive loading anvil, as well as the oven air, so that extremely good temperature control now was obtained.

After the specimen has come to full temperature, a load of 400 pounds was applied rapidly, the machine shut off, and the decay of load-with-time recorded These tests were made at several temperatures, and 95° C. chosen as the temperature for further tests. Results from a number of such tests are given in Table 1.

A lot of material was subsequently received which had evidently been undercured by the vendor. Baking this material for 24 hours at 125° C. advanced the cure sufficiently so that it was brought within limits.

The springs machined from the tube had to endure more or less indefinitely an axial force of 0.3-pound at temperatures not to exceed 80° C. Accordingly, a load of twice this value, or 0.6-pound, was chosen for the test.

The spring was tested by supporting it vertically from one end, and suspending a load on the bottom so as to elongate the spring slightly. A rod with a machinist's steel scale marked off in hundredths of an inch extended out the bottom of the spring, and served to measure the spring extension. To suspend this assembly in an oven was no problem, and the scale could be read to hundredths of an inch with great accuracy by means of a telescope on a transit outside the oven.

Table 1. Relaxation Properties of Molded Glass-Epoxy Sleeving Tubing (load held three minutes at 95° C.).

Sample No.	Load, Lbs.	Load Relaxation	
		Pounds	% Load
1	400	25	6.25
2	400	23	5.75
3	400	27	6.75
4	405	24	5.95
5	407	22	5.4
6	405	25	6.2
7	408	18*	4.4*

* Specimen post-aged 24 hrs. at 125° C.

Filament-Wound Hoop

Large hoops are critical components of large electric generators. Acting in concert with other structural members, these hoops support that portion of the generator winding that is not actually within the laminated iron core. Should such a generator experience a sudden short circuit when delivering full power, outward forces in the order of 80,000 pounds must be contained by these hoops and associated supports. The hoops operate in intense magnetic fields, and in close proximity to sources of high voltage, making a non-metallic part inherently desirable. These hoops are filament wound, and replace similar, heavily-insulated hoops made of non-magnetic stainless steel.

The critical nature of this part required extensive evaluation before the change from stainless steel to reinforced plastic could be approved. The development program for these hoops required G-E's largest testing machine. With this equipment, welds in the stainless steel rings were cracked, while comparable glass-fiber hoops were taken to the limit of the machine without damage. When this design of hoop reached the production stage, it was required that a nondestructive quality-control test be made on these parts without recourse to such elaborate facilities.

The method whereby such a test was developed will be described. The duty on these hoops is in the form of radially-outward forces producing tensile stress in the ring. The ring is so enormously strong in this mode of loading that no simple equipment could produce a significant tensile stress.

It was first necessary, therefore, to devise a mode of loading the finished hoop to procure a readily measurable strain or deflection with a load that was convenient to handle. Loading the hoop across its diameter

is an obvious means to accomplish this. The load to be borne was calculated to be such that the maximum bending stress in the ring did not exceed 20,000 psi. Based on these results, a load of 204 pounds was hung across the ring so as to distort it into an ellipse. A simple slide caliper with a spring-loaded return was mounted across the diameter of the hoop on a pair of telescoping tubes. The diametrical increase of the 204 pound load was slightly less than one inch.

Elliptical distortion for a 72-inch diameter ring vs. temperature is shown in Figure 6. This plot shows the development of rubber-like elasticity in the temperature range of 100-125° C., and plastic deformation above 125° C. The test temperature was selected as 122° C., at which rubbery properties are well defined, but just below the temperature at which plasticity becomes evident.

From other studies on unidirectional fiber specimens, the reproducibility of cure of the resin system, and on early experience with what was attainable in production, an elliptical distortion measured after three minutes of loading at 118 ±2° C. which would calculate back to a modulus of elasticity of 4.8 x 10^6 psi. was taken as the lower limit of acceptance. Acceptance values then were calculated for rings in a wide variety of diameters.

General Discussion

This paper has attempted to show that with very low stress levels, one can demonstrate a transition from classical elasticity to rheological behavior in reinforced plastics with increasing temperature. It is further stated that these effects may be interpreted to give valuable information about the quality of the part. It is now proposed to make a critical assessment of the potentialities of this approach.

As presently developed, the universal application of this method is somewhat beset with gadgeteering problems. Cases are readily foreseeable where it will be difficult to impose known loads at elevated temperature, and simultaneously measure strain or deflection. This is particularly true with parts of large size.

English authors (3) have shown that transition temperatures may be detected by measuring the rebound height of a falling ball. The material is elastic and the rebound height is high when the resin is either glassy or rubbery. At the middle of the transition, the material is neither glassy nor rubbery, so that a "dead" response to a falling ball is obtained. The temperature of maximum energy absorption is taken as the glass point. Gordon and Grievson have shown that the glass-point by this method changes with cure and degree of cross-linking in both clear resins and glass fabric-reinforced panels. There are a number of other experimental methods used to study transition phenomena, and perhaps it is not too much to hope that some instrument may be devised that will replace the somewhat-cumbersome loading methods described in this paper.

It is also possible to encounter resin systems which do not respond well to this approach. Examples of these are the so-called general-purpose resins containing a large percentage of phthalate, and in the very highly cross-linked, high-temperature phenolics. In the former case, once the glass point is reached, the resin develops plasticity so rapidly that it is difficult to avoid destroying the part. On the other hand, some phenolics are so highly cross-linked that it is necessary to use temperatures above 200° C., and stresses that are a major fraction of the rupture strength to demonstrate any departure at all from glassy properties. In between these extremes lie a majority of the commercially-important polyester and epoxy resins, and the experience to date has been favorable with these types.

Conclusions

Quality-control procedure may be based on observing the creep or relaxation of parts heated slightly above the glass point when lightly stressed.

The temperature and stress combination for these purposes is highly specific for each application, and must be determined by experiment.

The test is considered nondestructive if the imposed stress is known to be a small fraction of the rupture strength, and if any deformation imposed on the part by the test is found to be recoverable.

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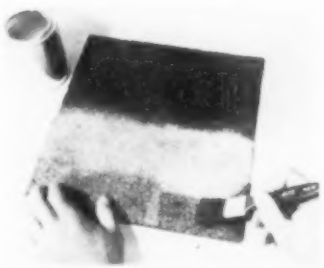
—THE END



Asphalt shingle in various stages of revitalization.

Reroofing with Polyurethanes

Old asphalt shingles take on new life when coated with Del-Coat liquid polyurethane and sprinkled with sand. A product of Delka Research Corp., New York City, Del-Coat is based on a diisocyanate combined with either a polyethylene or polypropylene copolymer. It is brushed onto the worn shingles with a regular paint brush. Two coatings are recommended.

The formulation actually reshapes weather-curled wooden shingles, according to company reports. Tests on metallic panels show the formulation to have an impact resistance of 160 inch-pounds (Gardner) using a four-pound steel ball.

—THE END

PLASTICS TECHNOLOGY

EXPLORING FABRICATION TECHNIQUES

By L. J. ZUKOR, *Engineering Editor*

Improved Fabrication Techniques . . .

. . . are creating new and sizable markets for the fluorocarbon resins. One of these, a method of fabricating flexible hydraulic hose for corrosive service, has been tried successfully and is presently being used in production. Titeflex Inc., Springfield, Mass., developed the new method and is producing liners made from TFE tape with helical convolutions.

This convoluted liner exhibits greater flexibility than any other type of TFE hose, and was specifically designed to satisfy demands made by the aircraft, missile, petroleum, chemical, and steel industries. Previously, hose was extruded from TFE resin (see extrusion method, our June issue, page 52) reinforced with wire braid. Such construction limits flexibility to small diameter hose sizes with relatively thin wall sections. In the larger sizes, the TFE inner core becomes too rigid for easy flexing. The design also limits bend radii to 8-10 times the inside diameter with no guarantee that the hose assembly will not kink at the inside radius and collapse in service. By comparison, the new hose is manufactured in sizes up to two inches and can be bent to a radius of three and one half times the inside diameter.

Titeflex's process for manufacturing the new hose (known as "Springfield 400") uses a special machine consisting of a contra-wrap head with tensioning equipment somewhat similar to that used in communications cable wrapping. At this point the similarity ends, since there is also a revolving mandrel and die with tapered helical convolutions. When the TFE-glass laminate inner core emerges from the die, it is cut to 25 foot lengths. After cutting, these are fed into a convection-type sintering oven where the TFE resin is reduced to its gel state. This occurs at a nominal temperature of 620°

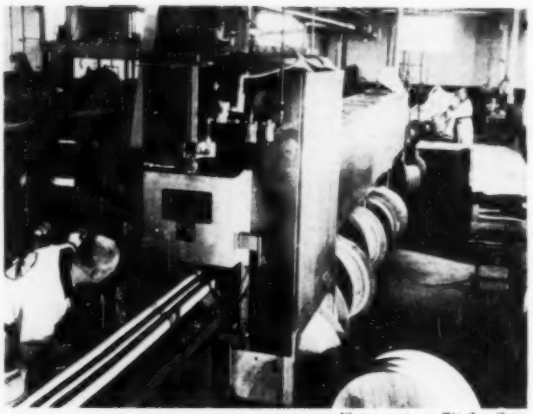


Photo courtesy: Titeflex Corp.

Sintering operation for TFE hose.

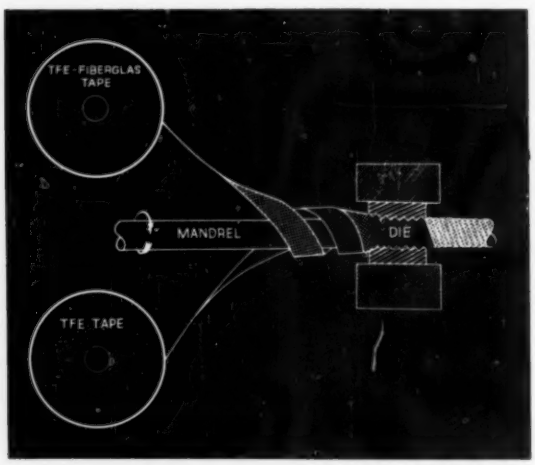


Diagram courtesy: Titeflex Corp.

Wrapping machine diagram.

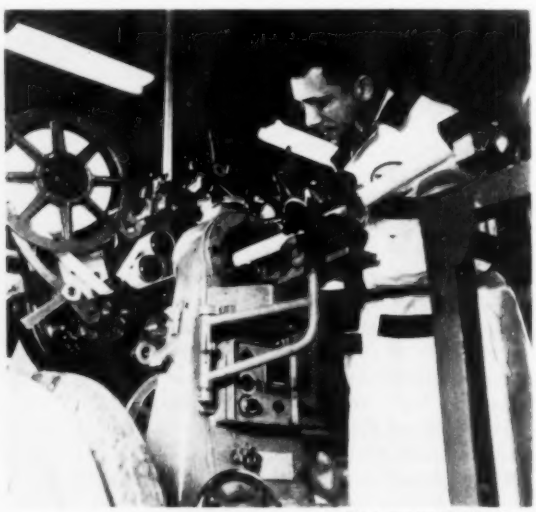


Photo courtesy: Titeflex Corp.

Springfield 400 automatic core machine.

Photo courtesy: Titeflex Corp.

Water quench after sintering.

F., at which point the wrapped TFE tape and the TFE-glass tape are permanently fused as a laminate. Temperature control instruments adjust and hold a constant temperature in the ovens to ±5 degrees.

The hoses are immediately quenched by water spray as they emerge from the oven. A fast quench is used so that the desired physical properties of the TFE resin may be retained. After the inner core is cooled and dried, the hose is wound on storage reels. Further fabrication, when ordered, consists of applying a stainless steel braid and stainless steel fittings. During the braiding operation, the inner core is radially compressed by the braid so that the inner core is assembled with a built-in compressive stress which is negated in service when a pressurized fluid in the hose places an opposite tensile stress on the TFE inner core. The braid is designed to restrict elongation, contraction, and cubical expansion of the hose assembly.

The "Springfield 400" hose is recommended for temperature up to 400° F. The tensile strength of Teflon, the Du Pont TFE resin used in the hose, exceeds 3,000 psi. at room temperature, but will drop off to less than 1,000 psi. at 400° F. Also, Teflon will deform up to 20% when stressed to 1,000 psi. at 400° F. for several hours.

The unusual combination of useful characteristics shown by TFE resins has not yet been equalled. This new hose design is yet another in a growing list of products made of a very versatile plastic.

•

Flexible Polyurethane Foam . . .

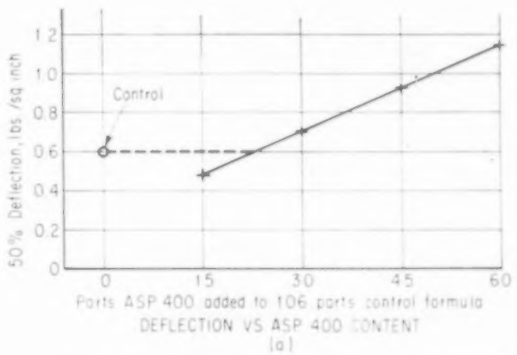
. . . has been extended successfully, thus reducing foam costs substantially and providing the formulator with a means to control his end-product's physical characteristics. The material used for this purpose is an aluminum silicate pigment, prepared from refined Kaolin. (See our March issue, page 53.) This announcement is the result of a three-year research program conducted by Minerals & Chemicals Corp. of America, who reports that excellent results have been achieved with both prepolymer and one-shot foams.

Although cost savings is probably the most significant factor, the use of a mineral pigment as an extender can predictably alter the foam's physical characteristics. Controlled resilience, greater resistance to burning, and better insulating effects have been achieved. Many of the extended foam formulations were found to have better shock absorption characteristics. This suggested that in applications such as automotive crash padding and rug underlays, thinner foams are not only more economical, but as practical as conventional foams. Cushions of stiffer, extended foams could be cored to present further material savings without sacrificing the comfort features of solid foams. Extending stiffer foams might also be the answer to commercially-feasible, airless automotive tires.

The tests conducted at the laboratories of Minerals & Chemicals Corp. consisted of experimenting with several prepolymers. The first prepolymer used had the following formulation:

	Parts by Weight
Polypropylene glycol (1,000 combining wt.)	2200.0
2,4, Tolylene diisocyanate (first charge)	200.0
2,4 Tolylene diisocyanate (second charge)	539.0
N-methyl morpholine	1.1
Total	2940.1

Weight, lbs. per gallon	8.8
Yield in cubic feet per gallon of prepolymer	2.66
Yield in cubic feet per 100 lb. of prepolymer	30.2



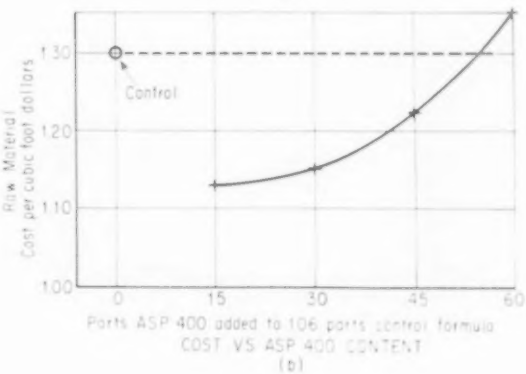


Figure 1

Graphs courtesy: Minerals & Chemicals Corp.

(Continued on page 63)

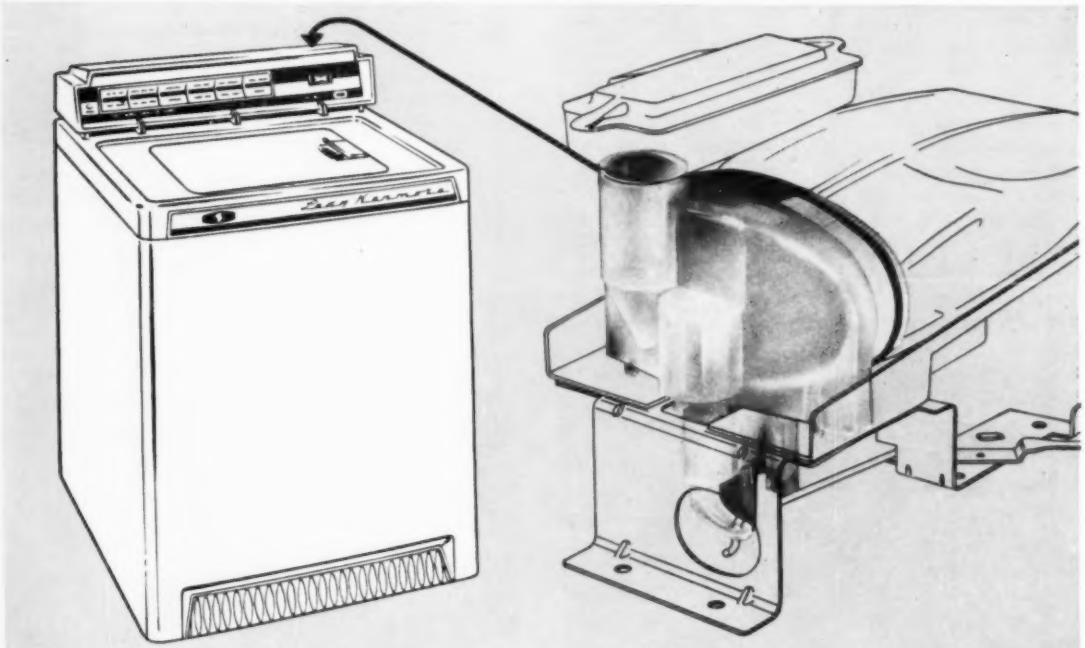
HERCULES

Plastics Hi-lites

Hidden values with new plastics

The inside story of seldom-seen parts performing demanding roles in new equipment

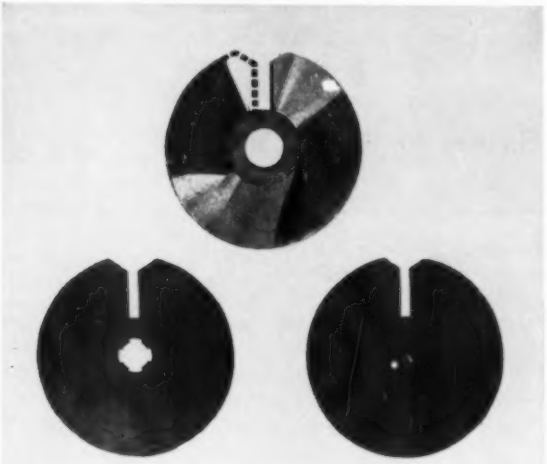
Today's consumer is prone to take advanced engineering features of new products for granted. Industrial users, too, have come to expect superior performance and greater serviceability from every piece of new equipment. Here are a few of the ways that design engineers are using Hercules new plastics to build added values into their products without increased cost. Able to work for the first time with thermo-plastics which are truly structural materials, they have found it possible to make one part do the work of many. Rapid-cycle injection molding produces the new precision-formed units at low cost, and the properties of the new materials provide the stamina and durability which assure faithful, trouble-free service.



Handsome styling, luxurious appointments, and its many extra service features have made the Lady Kenmore Clothes Washer one of the nation's best sellers. But it's the engineering and quality of construction inside the Lady Kenmore which enables Sears to maintain its reputation for *big value* merchandise. A significant example is the advanced design of the rinse dispenser developed by The Dole Valve Company, Morton Grove, Illinois, especially for this outstanding machine. The heart of the unit (shown in position in the diagram with the rest of the assembly in outline) is precision molded with Pro-fax®, Hercules' polypropylene. Pro-fax, the newest and most versatile of thermoplastic, provides a part that is immune to rust and the corrosive attack of detergents, highly resistant to heat, mechanically strong, and functionally sound.

How a one-piece Penton® Part replaced five individual parts

When Economics Laboratory, Inc. developed its new Drymaster*—a proportionate pumping system to automatically dispense its nationally known line of chemical formulations for commercial dishwashing—it faced the problem of finding a material to replace its conventional 5-piece bronze disc and carbon half-ball assembly. Failures in the Drymaster after only a few months of service were directly traced to wear of the disc and half-ball, and Economics Laboratory thoroughly evaluated more than 150 materials before selecting Penton®. The success of Penton in the Drymaster is typical of the way this versatile new thermoplastic can be precision-molded to provide superior, low-cost replacements for expensive machined metal parts.



Here's dramatic evidence of Penton's superior wear characteristics after 100,000 gallons of 220°F. hot-water service. Slot in bronze disc (at top) has worn away to an extent that the meter no longer functions accurately Penton test disc (at left) remains relatively unchanged after same exposure, as compared with production line part (right photo).

Although one of the newest of plastics, Penton chlorinated polyether was exhaustively tested during five years of product evaluation prior to its recent introduction as a commercial material for use in such applications as: valves, pipe, fittings, tank linings, pump and meter parts.

For complete details on Penton, including a folder charting Penton's resistance at elevated temperatures to more than 250 chemicals, call or write Hercules.

Tradename of Economics Laboratory, Inc., St. Paul, Minn. Information regarding meters and Disc and Half-Ball Assemblies is available from the Industrial Division, Economics Laboratory, Inc., St. Paul 1, Minnesota.

Design Hi-lites

The idea of forming a complete plastic container having a molded hinge and catch to join the body and the lid is not new. However, prior to the advent of Pro-fax® polypropylene, it was not possible to achieve a tough, rigid unit of this type, with a hinge of virtually unlimited flex life and a tight-fitting, easily operable fastener.

The economic advantages of such an assembly —whether it is designed to serve as an appliance housing, in luggage, or for consumer packaging— are readily apparent. Fittings can be eliminated, together with the costs of finishing and assembly. In many instances, the completed part emerges from the mold, ready for shipment and use.

Whether you expect to use Pro-fax to exploit this special design feature, or because of its many other desirable properties, we'll be glad to help you with your product planning. Our technical service group has had extensive experience in designing, engineering, and processing Pro-fax for products of all types. It can assist you in the development of parts which will take optimum advantage of the properties of this versatile plastic, and, at the same time, minimize processing, finishing, and assembly problems.

A fine example of a handsomely styled new product which "hinges" on Pro-fax is the "Platter Porter", a new phonograph accessory which promises to become a teen-ager's "must". Designed and produced by Columbus Plastic Products, Columbus, Ohio, this portable case for 45rpm records is lightweight, colorful, with a striking leather-grain finish impervious to weathering, staining and hard knocks. With a molded hinge and catch, there's no risk of breakage at these key points, and at the same time this new approach to luggage design greatly simplifies assembly and finishing problems.

CP59-20

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

HERCULES

THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

Edited by:
R. H. HOEHN, *Chief Engineer*
Mack Molding Co., Inc.
Wayne, N. J.

Injection Molding: Mold Finishes for Polyolefins

IN response to my introductory article in the October issue requesting reader participation, we received a rather timely reminder from Mr. Albert Spaak, Technical Service Supervisor, Polymer Chemicals Division of W. R. Grace & Co., Clifton, N. J. His remarks are as follows:

Mold Finishes for Polyolefins

In many injection molding applications, we are confronted with the problem of the finished appearance of the molded article. The product designer usually gives first consideration to the texture of the molded product with regard to product saleability. The functional finish of the application also is a very important consideration. The surface finish of the injection mold not only enhances the appearance of the molded article, but also can help in the molding of the article when using a polyolefin.

Due to the high shrinkage factors of the polyolefins, when compared to other plastic materials, it now is possible to texture vertical draw surfaces of the mold which had not been possible with other materials, at least not to the extent now practiced.

A textured mold surface has much to offer towards producing better parts. It affords a more scuff-resistant surface. Molding problems, such as warpage, are minimized with the use of lower melt-index polyolefins. Production can be increased due to lower mold and material temperatures. Roughened surfaces aid in mold release and also improve the flow of the molten polymer. There are several surface treatment methods in common usage at this time, a summary of which may be of interest to the reader.

Chrome Plated Surfaces

Chrome plating the mold becomes necessary in many cases in order to obtain a high-lustre finish, but requires a specialized skill. The basic mold must be polished properly because chrome plating will only accentuate any defects. The chrome actually is protecting the highly polished surface of the mold from corrosion, scratching, and pitting. Chrome, however, does not become a mold-release aid for polyolefins, but is helpful in this respect with most plastics. Chrome plating is vulnerable to chipping. If a section of the cavity is reworked and requires chrome plating, the whole cavity must be stripped of chrome plate and re-plated. Only those chrome plating companies who have worked closely with moldmakers are successful in doing the type of job which will give excellent service in production runs.

Vapor-Honed Surfaces

Vapor-honing a mold usually is done by the moldmaker. Finely-divided carborundum powder is dispersed in water under high pressure. The carborundum-containing liquid is impinged on the surface of the cavity or core as the case may be. Minor surface imperfections from carborundum cloth finishing are hidden by this mat-type finish and the cost of mold finishing can be kept to a minimum. Vapor-honing is not as permanent as other types of finishes, and the finish may wear off in spots due to constant injection of plastic material into the cavity. In most cases, however, it is very suitable for the production runs required. The molded parts will have a soft mat appearance,

but are not entirely scuff-resistant.

Sand-Blasting Surfaces

Sand-blasting produces a rough surface, the texture depending on the type of carborundum grit used. Some companies are presently specializing in various grades of sand-blasting. A monument maker who uses sand-blasting equipment to engrave headstones is also a good source for having this type of work done. In all cases, the toolmaker should caution the monument maker to avoid damage to parts of the mold that should not be sand-blasted. These surfaces usually are protected by applying pressure-sensitive rubber tape to the surface. Sand-blasting is powerful and accomplishes its effect in a matter of a few seconds, so extreme care must be used in the blasting operation.

Die-Engraved Surfaces

To die-engrave a surface of a mold means that a tool-and-die maker skilled in the art of die engraving mechanically produces an appropriate texture on the cavity surface. Certain types of punching tools are used to produce a repetitive type of pattern effect on the mold surface. Since die engraving actually is upsetting the soft steel surface, work cannot be done after hardening a mold. Some of the effects produced are very decorative on the finished molded item. Polyolefins become very scuff-resistant due to the coarse texture resulting from such die engraving. This method makes it possible to create a texture on surfaces in remote areas of the cavity and also to confine the texture to specific areas. One must be careful to select a competent tool-and-die shop that can do this specialized type of work. There are some companies who specialize solely in die engraving. In many cases, the tool-and-die company will work directly with such a concern.

Photo-Arc Engraved Surfaces

This method of producing a textured surface on a cavity is not new. It has been used successfully for many years in the textile industry to reproduce patterns of various designs on copper printing rolls. Only recently, however, this technique has been adapted to the mold-making industry. The desired pattern is first designed on paper. It is then photographically reproduced on the treated cavity steel surface. —THE END

Flexible Polyurethane Foam

(Cont'd. from page 59)

The polyglycol was combined with the first charge of diisocyanate and heated, raising the temperature to 158° F. in one hour. After holding this temperature for 2¾ hours, the second charge of diisocyanate was added over a period of an hour while the temperature was held constant. This produced a prepolymer having a minimum viscosity of 1,500 cps. Although this prepolymer is not normally found in use, it does serve to illustrate the function of the extender.

Aluminum silicate pigment (ASP) was added to the prepolymer and mechanically mixed for about two minutes until uniformly dispersed.

The following catalyst mixture was added to each 100 parts by weight of prepolymer:

	Parts by Weight
DC 200 (50 cps)	0.5
Water	2.3
N-methyl morpholine	2.0

The material was poured into a box mold and allowed to cure for 15 minutes at 158° F. When removed from the mold, the foamed material was post cured for four hours at 176° F. Properties of the extended foam prepared in this test showed an increase in density from a value of 3.23 lb./cu. ft. to 3.39 lb./cu. ft. Other favorable properties were observed; compression set showed a decrease from a control of 21.0% to about 19.0%, and a very slight gain in pressure at 50% deflection from 50.0 psi. to 54.0 psi.

Extender behavior in "one-shot" foam formulations was also studied. The following formulation, costing approximately 42.1 cents per lb., was used:

	Parts by Weight
Polypropylene glycol (1,000 combining wt.)	100.0
Nacconate 80	37.0
Dabco, triethylene diamine	0.7
Silicone X 520	0.7
Water	3.0
Total	141.4

Deflection values were found to be linear (Figure 1a) allowing the formulator to select the required mixture. On a cost basis, with ASP 400 at 3 cents per lb., the point at which the mixture will reach the price of unextended foam will occur at about 55 parts by weight of ASP 400 per 106 parts by weight polymer (Figure 1b).

In the tests, the viscosity of the polyglycol-extender mix was also considered. Up to 60 parts by weight ASP 400 induced some thixotropy when mixing was started, which readily broke down with continued agitation.

Minerals & Chemicals Corp. observed that the extended foam does not shrink as much during the post-cure cycle. Apparently the solid mineral particles block complete recoiling of the polymer molecules after initial chain extension.

The mineral extenders tested exhibited varying suspension properties. However, there was no stability problem for eight hours with any of the extenders. This seems adequate for most applications. Large batches were made in the laboratories to check the effect on larger foam volumes. In one case, the large foam batch was found to be fine-celled and uniform.

Studies of the effect of extenders in polyurethane foams are continuing at the Minerals & Chemicals Research Center. Currently investigations are being made on tensile strength and elongation of extended foams. Initial results indicate that at low extender concentrations both properties are improved. —THE END

NEWS of the Industry

new plants, labs & additions

Borden Chemical Co. has completed construction of its $500,000 plant in Illiopolis, Ill., for the coatings and adhesives department. Occupying 24,000 square feet of floor space, it provides facilities for general manufacturing, warehousing, solvent processing, offices, and a tank farm.

B. B. Chemical Co., a subsidiary of **United Shoe Machinery Corp.**, has expanded its service laboratory facilities at Cambridge, Mass. New labs will cover 1,600 square feet of space, and will be devoted to adhesives application engineering and bond testing.

Carbic-Hoechst Corp., Hostachem Corp., and Hostawax Co. have moved to a new plant at Mountainside, N. J. The firms are technical representatives and distributors for **Farbwerke Hoechst AG.**, West Germany, and **Hoechst Chemical Corp.**, West Warwick, R. I.

Colorite Plastics of New Jersey, Inc., has built a new, 15,000 square-foot addition to its plant in Paterson, N. J. Capital investment in building and machinery will exceed $500,000.

Dow Corning Corp. will erect a technical service and development laboratory in Greensboro, N. C. The facility will be adjacent to the firm's other plants, and will be part of the product engineering department.

Eastman Chemical Products, Inc., has opened a sales office in Fort Washington Industrial Park, Philadelphia. Thomas L. Loveless directs the operation.

Emery Industries, Inc., has announced a $6-million plant expansion project at Cincinnati, O. Existing capacity for azelaic and pelargonic acids, produced from oleic acid by ozone oxidation, will be increased several fold.

General Aniline & Film Corp.'s dyestuff and chemical division has re-engineered its acetylene derivatives plant at Calvert City, Ky. Rated capacity will be increased considerably.

Industrial Nucleonics Corp. has moved into its new research, engineering, and manufacturing facilities near Columbus, O. The 75,000 square-foot plant accommodates 600 employes and comprises approximately one-fifth of a projected future center.

Moreland Corp., manufacturer of printing and industrial rollers, has enlarged its plant in Willow Grove, Pa., by about 30%. The addition is devoted exclusively to production.

Plastics Horizons, Inc., producers of polyethylene packaging film, just opened a Midwestern plant at Batavia, Ill. It occupies 27,000 square feet of a 17-acre tract. Home offices are in Paterson, N. J.

Leeds & Northrup Co. has opened a $2-million research center at North Wales, Pa. Covering 65,000 square feet, the building is so designed that it can be tripled in size. A staff of 129 scientists will be employed under the direction of Raymond C. Machler.

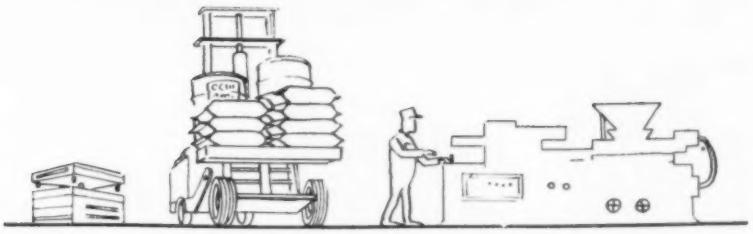
Rubber & Asbestos Corp., manufacturer of industrial adhesives, has opened a Midwest sales office at 3553 West Peterson Ave., Chicago 45, Ill. The firm's headquarters are located in Bloomfield, N. J.

Union Carbide Plastics Co. has opened a 80-million pound-per-year low-density polyethylene plant at Whiting, Ind. This brings the firm's total capacity to 400 million pounds annually.

business developments

Erratum. In September, we reported that **J. P. Frank Chemical Corp.** planned to increase its PVC, vinyl stearate, and vinyl acetate copolymer facilities by ⅓. Actually, the company has already done this, and plans called for eventual 100% expansion. Our regrets.

Cadillac Plastic & Chemical Co. has announced the availability of Delrin sheets, rods, and tubes. Prices will be approximately the same as those for nylon.



Allied Chemical's National Aniline division has formed a new technical service group under the direction of J. E. Loughlin for handling of isocyanate and urethane problems. A new marketing program for these materials has been announced, with J. W. Hill as product manager. He recently estimated that 75-100 million pounds of flexible polyurethane foam will be produced and sold in 1960, mostly for furniture, bedding, and automotive applications. A practical method of molding polyurethane cushions should spur its use, according to company spokesmen.

Cast Optics Corp. now supplies all of the standard translucent and opaque colors in its line of Evr-Kleer cast acrylic sheets.

Majestic Molded Products, Inc., Bronx, N. Y., has announced a major expansion of its blow-molding operation. Five new machines have been installed. This operation was formerly known as **Mark-Smith Plastics Corp.,** and was operated as a separate division in Paterson, N. J.

changes in ownership & new companies

Electric Storage Battery Co. has acquired all the capital stock of **Chemical Linings, Inc.,** Watertown, N. Y. The latter firm will be supervised by **Atlas Mineral Products Co.,** an ESB subsidiary. Chemical Linings designs, fabricates, and installs corrosion-resistant linings, tanks, and towers; Atlas manufactures corrosion-resistant cements and fabricated plastic equipment.

W. R. Grace & Co.'s board of directors have approved the acquisition of **Endura Corp.,** Quakertown, Pa., and **Vellumoid Co.,** Worcester, Mass. The acquisition is subject to final audit and court license. Endura manufactures tape backings and impregnated papers; Vellumoid makes non-metallic gaskets.

Midland-Ross Corp.'s two subsidiaries, **John Waldron Corp.** and **Hartig Extruder Division,** have merged and will now be known as Waldron-Hartig Division. Operations will, however, remain as in the past.

Royell, Inc., is the name of a new firm recently set-up in Palo Alto, Calif. The company will serve as distributors of raw materials to the reinforced plastics industry. Officers are Roy E. Theiss, president; Robert Elliott, vice president, and Robert Ting, secretary-treasurer.

Standard Oil Co. (N.J.) and Humble Oil & Refining Co. plan to merge by the end of the year, subject to stockholder approval. All of the exploration, producing, manufacturing, marketing, and maring operations of the Jersey affiliated companies will be consolidated into the new company, which will have its headquarters in Houston, Tex.

news from abroad

A German life boat has been made of two layers of glass-reinforced polyester resin surrounding rigid PVC foam. Shaped like a submarine, the boat has clear plastic domes mounted fore and aft. It measures 26 by 9½ feet, will hold more than 40 persons, and will right itself from any position.

Alkali & Chemical Corp. of India, a subsidiary of I.C.I. (India) Private, Ltd., recently opened that country's first polyethylene plant. Located Rishra, near Calcutta, the plant has a capacity of 3,500 tons of Alkathene, the high-pressure I.C.I. polyethylene.

Montecatini opened its second ethylene plant in Ferrara, Italy. Designed by **M. W. Kellogg Co.** to produce 30,000 metric tons per year, the plant will also turn out 15,000 metric tons of propylene from the pyrolysis of naphtha.

Montecatini polypropylene film should be available shortly as biaxially-stretched sheets, 0.002-0.4 mm. in thickness. Intended for packaging, the film has a high degree of transparency, surface gloss, and exceptional resistance to mechanical stresses. Unoriented film will also be marketed for bags and food envelopes in thicknesses of 0.25-0.4 mm. It can be vacuum-formed.

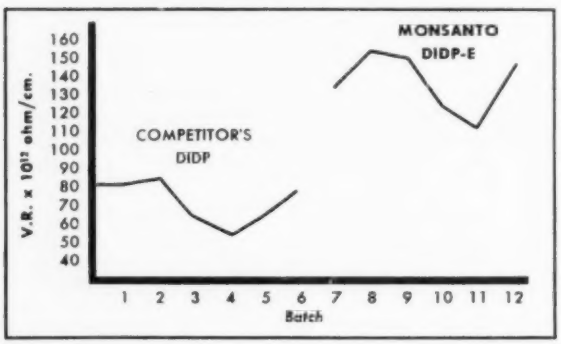
(Continued on page 84)

To meet stringent specifications for

10 MONSANTO PLASTICIZERS properties plus compounding

Ten Monsanto electrical-grade plasticizers can help you meet rigid standards for safe load-carrying capacity in wire and cable. They deliver highest properties consistently in electrical compounds and give you more "formulating flexibility" to compound for lowest cost—*highest profits*. Check the comparisons shown here, then write for more details, samples and compounding help from Monsanto's Plasticizer Council.

Consistent high quality, fewer rejects with **MONSANTO DIDP-E**



Dry slab volume resistivity tests at 50° C. on vinyl electrical compounds in commercial production show that Monsanto DIDP-E gives high, reliable results. See how Monsanto DIDP-E can give *your* electrical wire and cable added reliability at no extra cost.

Low-cost extender provides good electrical properties: **HB-40**

		50 parts* DOP	35 parts DOP* 20 parts HB-40
Dry slab, ohm-cm. x 10^{13}		7.6	18.9
Megohms/1000 ft., #14 Wire			
Water immersion	24 hrs. @ 25° C.	1100.0	1900.0
	24 hrs. @ 50° C.	100.0	180.0
	1 wk. @ 50° C.	200.0	310.0
	5 wks. @ 50° C.	170.0	260.0
	12 wks. @ 50° C.	150.0	260.0

*Formulation available on request

Insulation resistance tests show that HB-40, blended with a primary plasticizer, can actually increase electrical properties while it cuts formulation costs.

vinyl insulation...

FOR SPT INSULATION: SANTICIZER 160, SANTICIZER 165, SANTICIZER 636, SANTICIZER 630, SANTICIZER 603, DIDP-E, DOP, HB-40, TCP

FOR 60° T and TW INSULATION: SANTICIZER 160, SANTICIZER 636, SANTICIZER 630, DIDP-E, DOP, HB-40, TCP

FOR 80° C. INSULATION: SANTICIZER 636, DIDP-E, DOP, TCP

FOR 90° C. INSULATION: SANTICIZER 409, TCP, DIDP-E

FOR 105° C. INSULATION: SANTICIZER 409

give consistently high electrical "flexibility"

For permanence at high temperatures— SANTICIZER 409

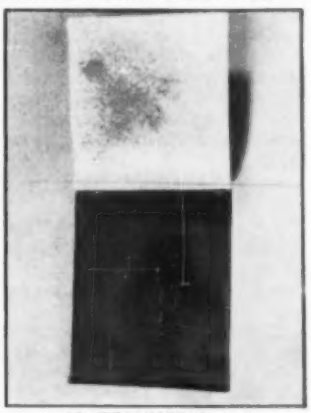
Electrical resistance tests show that SANTICIZER 409 gives high, consistently reliable properties compared with other plasticizers—yet is *lowest in cost.*

	Santicizer 409	Polymeric "A"
Insulation resistance, 1 day megohms/1000 ft. @ 50° C.	3.84	2.45
Dry slab, ohm-cm. x 10^{13}	12.5	4.85

High humidity doesn't cause exudation of SANTICIZER 409 as it does with some other polymerics. (See photo.) Vinyl-covered copper electrodes were immersed in water for 12 weeks at 50° C. A reaction between the copper and the plasticizer in the vinyl shows as a greenish color on vinyl cover (above the copper conductor) which indicates exudation and poor compatibility. The photo at left shows no reaction for SANTICIZER 409 while the electrode with polymeric "A" shows considerable discoloration.

No copper corrosion, no exudation with SANTICIZER 409

with SANTICIZER 409



with POLYMERIC "A"

SANTICIZER, HB-40: Monsanto T.M.'s. Reg. U.S. Pat. Off.

VITAL LITERATURE FOR ELECTRICAL COMPOUNDERS

- ☐ BULLETIN on SANTICIZER 160
- ☐ BULLETIN on SANTICIZER 409
- ☐ BULLETIN on SANTICIZER 630
- ☐ BULLETIN on SANTICIZER 165
- ☐ BULLETIN on SANTICIZER 636
- ☐ BULLETIN on SANTICIZER 603
- ☐ BULLETIN on MONSANTO DIDP-E
- ☐ BULLETIN on MONSANTO DOP
- ☐ BULLETIN on MONSANTO TCP
- ☐ BULLETIN on HB-40

Monsanto Chemical Company
Organic Chemicals Division
Dept. PL-4A, St. Louis 66, Mo.

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Address.....

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With no bias in favor of a single electrical-grade plasticizer, Monsanto develops plasticizing systems task-tailored to fit your needs best.

Monsanto

Names in the News

James C. Hahn

Cary Chemicals, Inc., has announced the appointment of five executives. **Elwood W. Phares,** formerly manager of market and commercial development department of Velsicol Chemical Corp., has been named sales manager. **Philip R. Scarito** has been promoted from works manager at Cary's East Brunswick plant to vice president in charge of compounding and calendering there. **James C. Hahn,** works manager at the Flemington plant, has moved up to vice president in charge of polymer division. **John C. Kancylarz,** who most recently was assistant treasurer, has been appointed assistant vice president, director of public relations and personnel. Mr. Hahn has been replaced as works manager for the Flemington plant by **Raymond T. Bohn, Jr.** Mr. Bohn has been with Cary since 1957.

Elmer F. Schumacher, formerly sales director of du Pont's Polychemicals Department, has been appointed special chemical and plastics consultant to the Commonwealth of Puerto Rico. Mr. Schumacher will analyze and evaluate manufacturing expansion opportunities in Puerto Rico for U. S. chemical and plastics producers.

William Pearson has been named sales manager of Molded Fiber Glass Boat Co., Union City, Pa. He was previously regional sales manager for the Eastern Seaboard. This district has been divided between **E. F. Bettes,** who will be responsible for the East-Central states, and **Norman Edgar,** who will cover New England and Central and Northeastern New York.

David E. Cordier has been appointed technical director of Mesa Plastics Co. He is the former director of Plaskon research and technical director of Carwin Polymer Products. Mr. Cordier holds over 20 polymer patents.

George W. Menkes has been elected vice president of Testing Machines, Inc. He was formerly associated with the United Motor division of General Motors, and has been sales manager of Testing Machines for the past four years.

H. R. Bishop has been appointed manager of the Middle Atlantic and Southern sales districts for W. R. Grace & Co.'s polymer chemicals divisions. Former vice president of Kautex, Mr. Bishop succeeds **Warren E. Peterson,** who has been named product manager, electrical grade polymers.

Herman F. Mark, professor of polymer chemistry at Polytechnic Institute of Brooklyn, won the 1960 William H. Nichols Medal of the American Chemical Society's New York Section. Dr. Mark will receive the award for research conducted on macromolecular structures during the past five years.

Robert J. Boyden has been appointed sales engineer specialist for F. J. Stokes Corp.'s recently-introduced blow molding machine. He was previously associated with Morningstar Corp. and E. B. Kingman Co.

William H. Eichelman & Associates have been appointed representatives for Alkyll Chemicals, Inc., in Michigan and Ohio. Alkyll makes cleaners, anti-rust lubricants, and products for the plastics industry.

Arthur H. Newton

Andrew A. Dukert

Andrew A. Dukert and **Arthur H. Newton** have been elected vice presidents of Penn-Plastics Corp. and its subsidiary, Penn-Plastics Manufacturing Co. Mr. Dukert, who had been chief engineer and assistant general manager, is now vice president in charge of engineering. Formerly director of manufacturing at Ethicon Corp., Mr. Newton is vice president in charge of manufacturing.

F. D. MacIver, Jr., has been appointed Chicago district sales manager for the closure & plastics division of Owens-Illinois. He joined the sales staff in 1951. **Edward A. Coleman** has been named Eastern manager.

Myron Petrakis

Efrem Ostrowsky

Efrem Ostrowsky has been named plant manager and chief engineer and **Myron Petrakis,** superintendent of the fabricating department at Federal Tool Corp. Mr. Ostrowsky was with Gits Molding Corp. Mr. Petrakis was promoted from superintendent of the vacuuming forming department.

Albert C. Tieniber has been transferred from New England to the Metropolitan New York, where he will continue to represent Chemo Products as a sales engineer. He is replaced by **Herbert Whitaker,** former head of the manufacturing division.

G. J. Esselen has been named sales manager for the industrial chemicals division of Pittsburgh Coke & Chemical Co. He formerly served as sales manager for the activated carbon division.

J. E. Gallagher has joined Marbon Chemical division, Borg-Warner Corp., as a sales-service extrusion engineer. He was formerly project engineer at Evanite Plastics, in charge of plastic pipe production.

Richard H. Hugger has been named senior department manager at U. S. Rubber Co.'s research center in Wayne, N. J. He joined the firm in 1947 as a mechanical engineer.

William H. West has joined the technical sales staff of Chippewa Plastics Co., with headquarters in Chicago. He previously served as assistant sales manager of Milprint, Inc., and with Reynolds Metals Co.

OBITUARY

John A. Vormbaum

John A. Vormbaum, secretary-treasurer and director at Lunn Laminates, Inc., died suddenly on September 6. Before coming to Lunn seven years ago, Mr. Vormbaum held positions as manager, Lockheed Aircraft Service, Inc.; chief area auditor, U.S. General Accounting Office; chief auditor, U.S. Corps of Engineers; and payroll supervisor, N. Y. World's Fair. A resident of Huntington Station, N. Y., he was a member of the Chamber of Commerce and SPI.

New Materials

Write item numbers on Readers' Service Card (p. 97) to obtain more information.

AviSun Polypropylene Polymer

AviSun Corp's polypropylene plant is currently producing several grades of polypropylene at the rate of 20-million pounds annually. Lighter than polyethylene (density, 0.89-0.92), it is molded at a higher temperature with no sacrifice in cycle time. Flow properties are good, and low pressures of 10,000-17,000 psi. can be employed without plasticizers. Pre-plasticizing units can be used to give a more uniform distribution of heat and shorter cycle time.

A typical polypropylene extruder should have a screw length 15-24 times its diameter and a compression ratio of 4:1. Melt temperatures range from 450-550° F. As a film, superior moisture vapor-barrier qualities over polyethylene are claimed. Experimental fibers are reported to have strengths greater than 6 grams/denier and elongations higher than 25%.

Typical properties are reported as follows:

Tensile strength, psi.	4,000-5,300
Elongation, %	250-700
Impact strength, ft. lbs./in. notch	0.4-1.5
Unnotched	30
Hardness, Rockwell R	85-95
Modulus of elasticity, psi. x 10^5	1.3-1.7
Stiffness, flexural, psi. x 10^5	1.1-1.7
Volume resistivity, ohm-cm.	10^{16}
Dielectric strength, volts/mil.	750-800
Dielectric constant, 10^6 cycles	2.1-2.2
Dissipation factor, 10^6 cycles	0.0002-0.0003
Water absorption	Nil
Effect of weak acids	None
Effect of alkalis	None
Effect of organic solvents under 80° C.	None to slight swelling
Burning rate	Slow
Specific heat, cal./°C./gram	0.45
Heat distortion point, °F.	220
Melting point, °F.	330-340
Mold shrinkage, in./in.	0.005-0.02

Readers' Service Item 1

Flexible Polyethylene Lacquer

For the first time, Rubbalac polyethylene lacquer makes it possible to paint and decorate polyethylene products without special treatment. Rubba, Inc.'s polyethylene ink is available in any viscosity, and may be applied with conventional silk screen, spray, or other equipment to treated or untreated polyethylene. It has excellent abrasion resistance, having withstood both the finger nail and scotch tape (offset) tests well.

The fast-drying ink contains highly-volatile toluene solvents which necessitate proper exhaust measures. As flexible as polyethylene itself, Rubbalac is available in a variety of transparent and opaque colors, and in white, black, and aluminum.

Readers' Service Item 2

Anti-Static Spray

Simco Co. has made available a non-oily, non-greasy, anti-static aerosol spray, Neutro-Stat. Sprayed onto plastic sheet, film, or parts, it will prevent attraction of dust and electrostatic shocks by forming an electrically conductive coating which may be washed off in water or alcohol. Neutro-Stat, it is claimed, will neither discolor nor haze clear plastic parts.

The spray, also available in bulk for dipping, wiping, or spraying, is recommended for television tube faces and safety screens, displays, phonograph records, and polyethylene bags, as well as equipment parts.

Readers' Service Item 3

Acrylic Polymers

Baker PL-11, an acrylic resin suitable for injection molding and extrusion, is reported to have better craze resistance than conventional acrylics. The water white transparent resin is odorless and tasteless, and may be machined.

Presently being market tested is J. T. Baker Chemical Co.'s PL-12, a straw-colored acrylic with fair transparency. PL-12 has a heat distortion point of 240° F., a flexural modulus of 415,000 psi., and a notched izod impact strength of 1.0 ft. lb./in. Properties of PL-11 include:

Heat distortion, °F.	244-267
Index of refraction.	1.519
Tensile strength, psi.	9,000
Elongation, %.	2
Flexural strength, psi., 77°F.	15,000
Flexural modulus, psi., 77°F.	480,000
Impact strength, milled notched izod, 77°F, ft. lbs./in.	0.3
Specific gravity.	1.17
Rockwell hardness, M.	102-105
Mold shrinkage, in./in.	0.003-0.007
Dielectric constant, 10^3 cps.	3.00
Dissipation factor, 10^3 cps.	0.028

Readers' Service Item 4

Light-Stable Epoxy Varnish

Union Carbide Chemicals Co.'s coating based on Epoxide-201 reportedly combines the best features of epoxy and alkyd varnishes. Free from light-sensitive phenolic ring structures, the material contains the epoxide groups necessary to form chemically-resistant polyether polymers.

Epoxide-201 may be used as a stabilizer for vinyl chloride. In comparison with bisphenol-glycidyl ethers, 201's resins feature high heat-distortion temperatures. Anhydride reactivity and ultimate resin properties of anhydride systems are generally improved by the addition of a polyol initiator. Epoxide-201 resins have relatively long pot lives. Its polymers containing free hydroxyls react with drying oils to form air-drying coatings. Properties of Epoxide-201 are:

Molecular weight	280.35
Specific gravity, 20/20° C.	1.121
Coefficient of expansion, 20°C./°C	0.00035
Boiling point, 5 mm. Hg, °C	215
Pour point, °F	30
Solubility in water, 20° C., % by wt	0.3
Solubility of water in, 20° C., % by wt	1.8
Viscosity, 25° C., cps	1,810
Refractive index, n_D, 20° C.,	1.4920
Flash point, open cup, °F	310

Readers' Service Item 5

Synthetic Calcium Sulfonate

Conoco Demivis, a synthetic calcium sulfonate in a plasticized system for use in making open-cell vinyl foam where blowing is completed before gelation, is commercially available from Continental Oil Co. The petrochemical is reported to be more compatible with PVC than oil-diluted sulfonates, and permits the use of a wider range of primary plasticizers.

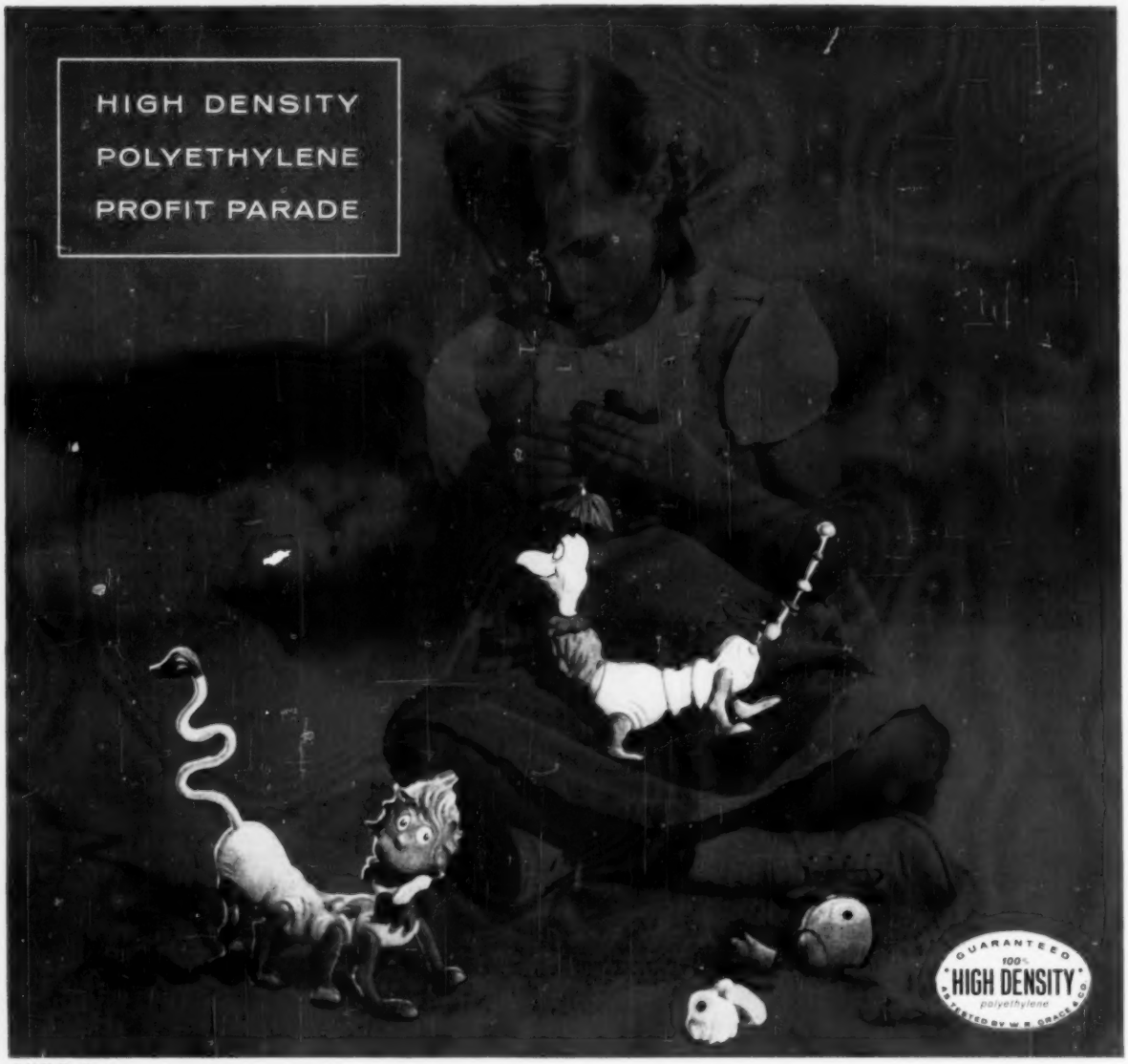
This low-viscosity, amber liquid is recommended for open-cell foam when ten pounds per cubic foot densities are desired, and especially in cases when the density is between five and seven pounds. Specific gravity at 60° F. is 0.937, while viscosity, SSU, at 210° F. is 71.1.

Readers' Service Item 6

Liquid Polyester Resin

Atlac L-382-13, a polyester resin with certain end-use characteristics approaching those of epoxies, has been developed by the chemicals division of Atlas Powder Co. Based on a bisphenol derivative reacted with fumaric or maleic anhydride, the resin is recommended for applications in which corrosion resistance or electrical and chemical resistance at elevated temperatures is important.

The amber liquid has a storage life of six months. Containing 33% styrene, it has a viscosity 11,000-15,000 centipoises and a specific gravity of 1.08. Using methyl ethyl ketone peroxide as catalyst, and cobalt naphthenate and dimethyl aniline as accelerators, the resin may be cured at room temperatures without losing chemical resistance and electrical properties.



©1959 Dr. Seuss

Play-proof Properties Spark New Product Idea

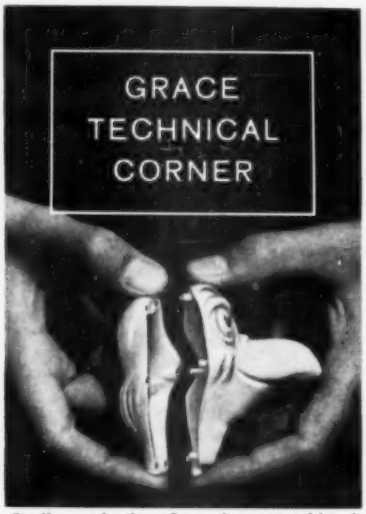
Developing a new product? Grex high density polyethylene could stir up as much excitement for you as it's doing for Revell, Inc. Their new product combines the toughness of Grex with the appeal of fantastic animal characters that roam the pages of Dr. Seuss' juvenile books. Sold in kits of interchangeable parts, Dr. Seuss Zoo inhabitants snap together and pull apart in millions of ways—are colorful and strong enough to take the roughest treatment without breaking, chipping or cracking.

There is virtually no limit to profitable new product applications with this versatile Grace plastic. Here are just a few of its advantages: It can be fabricated at low cost and molded in any color. It is a hard, stiff, rugged thermoplastic that takes boiling or freezing without losing its shape or strength.

Find out more about high density polyethylene for the new product you have in mind by calling in the experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. We're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION POLYMER GRACE CHEMICALS CLIFTON, NEW JERSEY



Quality production of complex parts achieved with fast cycles by specifying Grex.

Here you see 2 of 19 parts that make up Gowdy the Dowdy Grackle. Note their detail, irregularity of contour and how they snap together. In addition to Gowdy, Revell markets three other Dr. Seuss characters that are equally complex. The use of Grex high density polyethylene and substantial technical assistance from Grace helped Revell solve design and molding problems for this project. You can expect the same kind of benefits by working with Grace.

Design requirements of these Revell toys called for rigid parts with high impact strength. Resiliency was also needed to make snap plugs or poppets practical devices for snapping the parts together firmly and pulling them apart easily. Grex combines all three properties required—rigidity, high impact strength and resiliency. And the fact that the most intricate details can be molded with Grace's plastic provided freedom in reproducing these fantastic characters in three-dimensional shapes as suggested in Dr. Seuss books.

Mold layout and production. Revell's two molds for Dr. Seuss toys are among the most complicated ever used with Grex. They contain over 60 cavities; each cavity has an irregular parting line and many have serious undercuts. Stripping the parts from molds like these would have been either too slow for economical production or completely impossible with other plastics. High density polyethylene, however, solidifies in the mold at a high temperature yet remains flexible for stripping at fast cycles. Production efficiency was increased by using beryllium copper in many cavities and cores for effective heat removal.

Interested? If you have a job for high density polyethylene count on Grace for help. Now's the time to contact:

Technical Service Department,
W. R. Grace & Co., Clifton, N. J.

New Materials (Cont'd.)

Typical properties of ⅛-inch unfilled castings of Atlac L-382-13 are:

Specific gravity	1.15
Barcol hardness	39
Heat distortion, 264 psi., ° F.	284
Water absorption, 24 hrs., 73°F., %	0.20
boil, %	0.84
Flexural strength, psi.	15,000
Flexural modulus x 10^6	0.43
Tensile Strength, psi.	9,100
Tensile modulus x 10^6	0.40
Elongation, %	1.5
Charpy impact, unnotched	5.0
Dielectric constant, 10^6 cycles	3.18
Dissipation factor, 10^6 cycles	0.013
Arc resistance, seconds	112
Dielectric strength, v/mil.	400

Readers' Service Item 7

Plastic-Lead Putty

Devcon L, a putty-like material consisting of 94% lead and 6% thermosetting plastic, can be formed into any shape without heat or pressure. Made by Devcon Corp., the material has a working life of one hour and hardens in 2-4 hours at 75° F. It contains no volatile solvents and therefore shrinkage during hardening is only about 0.0005 inch per inch.

Originally developed for repairing lead-lined tanks and equipment in the chemical and allied industries, it also is being used for splicing and repairing lead cables and for making shields against radioactive materials. Once hardened, the mass is very similar to lead, and can be sawed, drilled, or machined with regular tools.

Readers' Service Item 8

Vinyl Molding Material

Marvinol VR-60, a polyvinyl chloride and vinyl acetate copolymer available from U. S. Rubber Co.'s Naugatuck Chemical Div., is a white granular powder intended for application in phonograph records and floor tile. Reported to have excellent filler tolerance, VR-60 has been approved for use in a vinyl-Fiberthin sealant. Described as soft, the resin processes at low temperatures and has good heat and light stability with the usual stabilizers. It is soluble in acetone.

Typical properties are:

Specific gravity	1.35
Specific viscosity, ave	0.20
Apparent density, lbs./ft.^{3}	35

Readers' Service Item 9

Reinforced Teflon Material

Rogers Corp. has added a bearing material of ceramic or glass microfibers, Teflon, and molybdenum disulfide to its line of Duroids. Homogeneous Duroid 5813 achieves lubricity from Teflon and resistance to cold flow and wear from the long fibers encapsulated within the plastic. Particularly suited for sleeve or water type bearings designated for operation at high and low ambient temperatures (—350°F. to 550°F.) and in corrosive atmospheres where lubrication may not be possible or desirable, Duroid 5813 is claimed to have better wear resistance and less cold flow than filled Teflons.

Typical properties of Duroid 5813 include:

Tensile strength, psi. M.D.	7,000-9,000
C.M.D.	4,000-6,000
Stiffness, psi., M.D., C.M.D.	120,000
Compressive strength, psi.	8,000
Flexural strength, psi, M.D.	10,000
C.M.D.	7,000
Deformation under load, %, 300°F., 1,200 psi.	0.4
2,000 psi.	1.0
Coefficient of friction, dynamic, 4,000 psi. load, 2 fpm.	0.018
Specific heat thermal conductivity, Btu./in., hr., sq. ft., °F.	2.1
Durometer (D) scale	73
Coefficient of thermal expansion, avg., 0°-100°F.	
Longitudinal	1.6 x 10^{-5}
Transverse	5.0 x 10^{-5}
Thickness (rod length)	15.0 x 10^{-5}
100°—350°F.	
Longitudinal	1.0 x 10^{-5}
Transverse	2.0 x 10^{-5}
Thickness (rod length)	11.0 x 10^{-5}

Readers' Service Item 10

Rapid-Cure Catalyst

Lupersol Delta, made by Wallace & Tiernan, Inc., Lucidol Div., is a clear colorless solution of methyl ethyl ketone peroxides and hydroperoxides in dimethyl phthalate. It was developed for the rapid gelation and cure of polyesters at room temperature. It can be used in reinforced plastic molding, hand lay-up, gel-coat work, and in the polyester repair kit field.

The chemical is stable for at least three months at room temperature.

Properties include:

Specific gravity, 25° C	>1.093
Refractive index, 25° C	>1.4480
Flash point, micro open cup, °F	>122
Decomposition, rapid heat test, °F	302
Active oxygen, minimum, %	11

Readers' Service Item 11

"...nothing but the finest plasticizers in our outwear materials"

Harte's WATASEAL®

Fred S. Strauss, President of Harte & Company, New York, says:

"My main goal in business is to make a good product and a reasonable profit. To accomplish this, we use only the best of plasticizers. Obviously, if we could reduce the cost of our raw materials, we could probably show a better profit, but what would happen to our product and our fine reputation for quality merchandise?

"When it comes to outerwear, it is no secret that vinyl fabrics must possess low temperature flexibility and the plasticizers we use for that product must give us this important characteristic and meet the strictest of specifications. Since we have a big stake in the future of the outerwear industry which we do not wish to jeopardize, we must never compromise on the quality and the performance of the raw materials we use."

Where the accent's on quality there's a preference for ***Plastolein® Plasticizers***

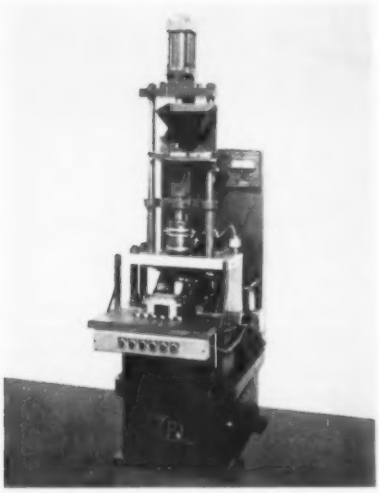
Emery

Organic Chemical Sales Department
EMERY INDUSTRIES, INC., CAREW TOWER, CINCINNATI 2, O.
Vopcolene Division, Los Angles; Emery Industries (Canada), London, Ont.
Export Department, Cincinnati

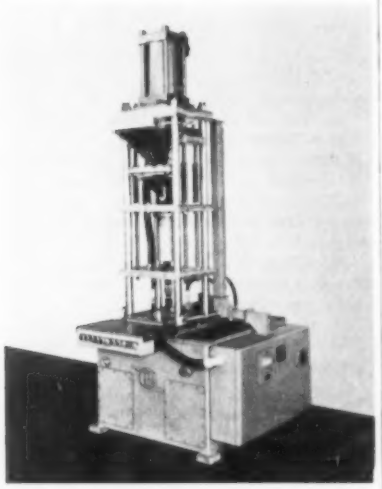
New Equipment

Write item numbers on Readers' Service Card (p. 97) to obtain more information.

Vertical Injection Machines



VMM-1 ounce vertical injector.



VMM-2 ounce vertical injector.

Progressive Tool & Die Co. has introduced both a one- and a two-ounce capacity, vertical, injection molding machine. They feature a special sliding table and push-button controls. Production cycles run about 600 per hour. Cylinder changes to accommodate different materials and colors can be made in minutes simply by removing two screws.

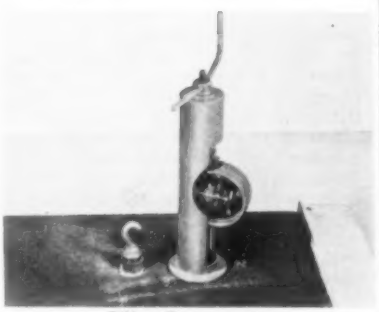
Locating pins in the upper and lower platens make mold positioning swift and accurate. Specifications for the VMM-1 and VMM-2 models are as follows:

	VMM-1	*VMM-2*
Floor space, in.	24x34½	40x53
Height, in.	87	109
Weight, lbs.	2,000	4,000
Shut height, in.	4	8½
Max. distance between platens, in.	7	10½
Injection plunger diameter, in.	1⅜	1⅝
Cylinder diameter, in.	4	8
Injection pressure, psi.	9,428	24,000
Injection stroke, in.	5½	8
Locating ring diameter, in.	1	4
Motor, hp.	2	5
Rpm.	1,800	1,200
Pump, gals./min.	4.8	17.8

Readers' Service Item 21

Tensile Testing Assembly

Combining a W. C. Dillon & Co., Inc., dynamometer with a screw jack and other common metal-working materials will make a portable instrument for measuring the strength of resinous and sheet materials or the holding power of adhesives. The testing assembly consists of two parts: a hook with a plug anchored to the material to be tested; and a dynamometer integrated with a screw jack. After the latter is placed over the anchored hook, with the hook and the dynamometer clevis joined, the jack is turned until the material gives way.



Dillon Dynamometer.

Customers "feel" for quality in vinyl outerwear

That's why a fine "hand" is so important for vinyl fabrics. And, many producers are convinced that Plastolein Low-Temperature Plasticizers endow their products with the very best hand . . . the soft, suppleness that "makes friends" with the buyer right from the start.

These Plastolein Plasticizers keep him sold, too, by maintaining this fine hand at all temperatures, particularly throughout the chill range. And not for just a few months but *for many seasons* . . . even after prolonged exposure to summer heat.

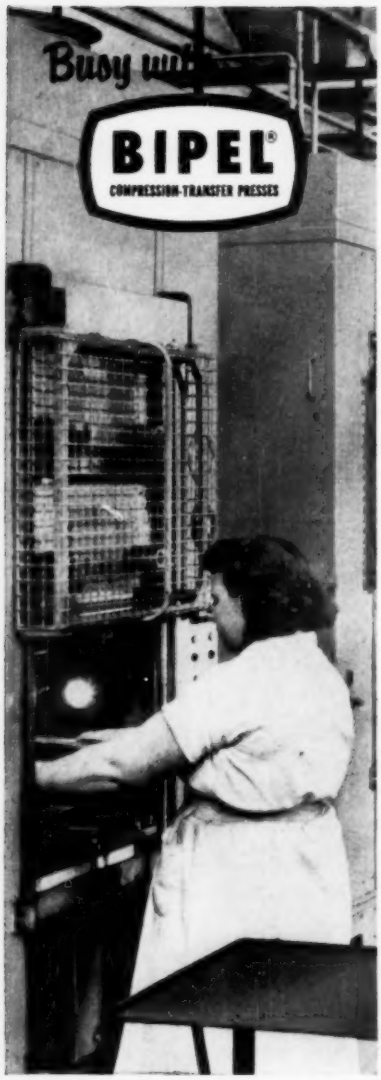
Emery offers two outstanding low-temperature plasticizers: Plastolein 9058 DOZ, the ultimate in low temperature performance; and Plastolein 9078 L. T., its lower priced counterpart.

Write Dept. Q-12 for literature.

PLASTOLEIN® plasticizers

Emery

Organic Chemical Sales Department
Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio
Vopcolene Division, Los Angeles
Emery Industries (Canada), London, Ontario
Export Department, Cincinnati



BIPEL molders are busy; their keen judgment in presses reflects in their sales. Their production is up with BIPEL Compression-Transfer Presses. "Auto-Control" means more cycles per hour, rejects virtually eliminated. 8 variable pressure ranges available from 24 to 660 tons . . . fully or semi-automatic, or manual control for complete flexibility.

Check BIPEL Service

Demonstrations, Information, Service and Parts always available at Tiverton, R. I. Make an appointment to see BIPEL Compression-Transfer PRESSES (and Horizontal Hydraulic PREFORMERS, too!)

B.I.P. Engineering Ltd. Sutton Coldfield, England

RALPH B. SYMONS ASSOCIATES, INC.
3571 MAIN ROAD, TIVERTON, R. I.

BIPEL
COMPRESSION-TRANSFER PRESSES
HORIZONTAL HYDRAULIC PREFORMERS

Dillon dynamometers are available in 13 capacities from 500 to 100,000 pounds, with five- or ten-inch dials. A five-inch instrument has a net weight of 8¼ pounds, and a gross of 14.

Readers' Service Item 22

Electrostatic Locator

Simco Co.'s Electrostatic Locator detects electrostatic charges and induction. Operation, which requires no previous experience, consists of pointing the probe of the meter toward the charged object. The linear scale of the meter, graduated in 5's from −10 to +10, indicates the polarity and relative magnitude of the charge. The meter may be adjusted to three sensitivity ranges.

Weighing less than three pounds, the Locator is powered by one standard flashlight cell and two standard 4½-volt dry cell batteries. Those parts of the instrument likely to be affected by moisture or dust are hermetically sealed.

Simco Electrostatic Locator.

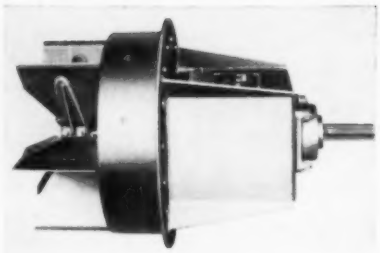
Readers' Service Item 23

Radial Blade Fans

Garden City Fan Co. has introduced a series of radial blade, high-temperature fans designed for service up to 1,850° F. Of the two basic types of fans, RF Thermal-Aire Fans are available with uninsulated or insulated housings, while RF Thermal-Aire Plug Units are offered without housing, with conventional RF fan housing, or with diffuser vane assembly. Gas-tight and corrosion-resistant construction can be furnished. Fans and plug units are rated at 60,000 CFM. and higher, at pressures up to 18 inches static pressure.

The blade design permits the wheel to intercept airflow into the fan with an angular scoop action which minimizes shock loss. Wheel sizes range from 14-71¼ inches diameter for both fans and plug units.

An Air-Cooled shaft is employed to protect bearings against heat transmission.



RF Thermal-Aire Plug Unit without housing.

A water-cooled shaft assembly is furnished when operating temperatures are to exceed 1,700° F.

Readers' Service Item 24

Lift-and-Dump Conveyors

Conveyors and Dumpers, Inc., has added the Cesco Jr. Model DU to its line. Useful for dumping any free flowing materials or parts, the unit may be adapted to handle drums, bags, boxes, barrels, and inplant containers with a capacity up to 400 pounds. The portable model will dump from a height between 2-8 feet.

The unit is 36 inches deep and 46¾ inches wide. Total height is dumping height plus 45 inches for a machine handling drums, and dumping height plus 38½ inches for box or bag types. Model DU will dump a box or bag 40 by 49¾ inches and a drum 45 by 49¾ inches at a 45° angle. It operates on a ½-hp. motor at 20 rpm.

Cesco Jr. Model DU.

Readers' Service Item 25

for a tough sign plastic...**BUTYRATE**

Durable signs, with letter faces vacuum-formed from sheets of Tenite Butyrate plastic, now identify J. I. Case Co. dealers to tractor, farm implement and industrial equipment buyers throughout the world.

Butyrate sheet's brilliant luster gives these letters an eye-catching, eye-pleasing appearance in daytime; and its excellent light transmission and diffusion properties provide long-distance legibility when backlighted at night.

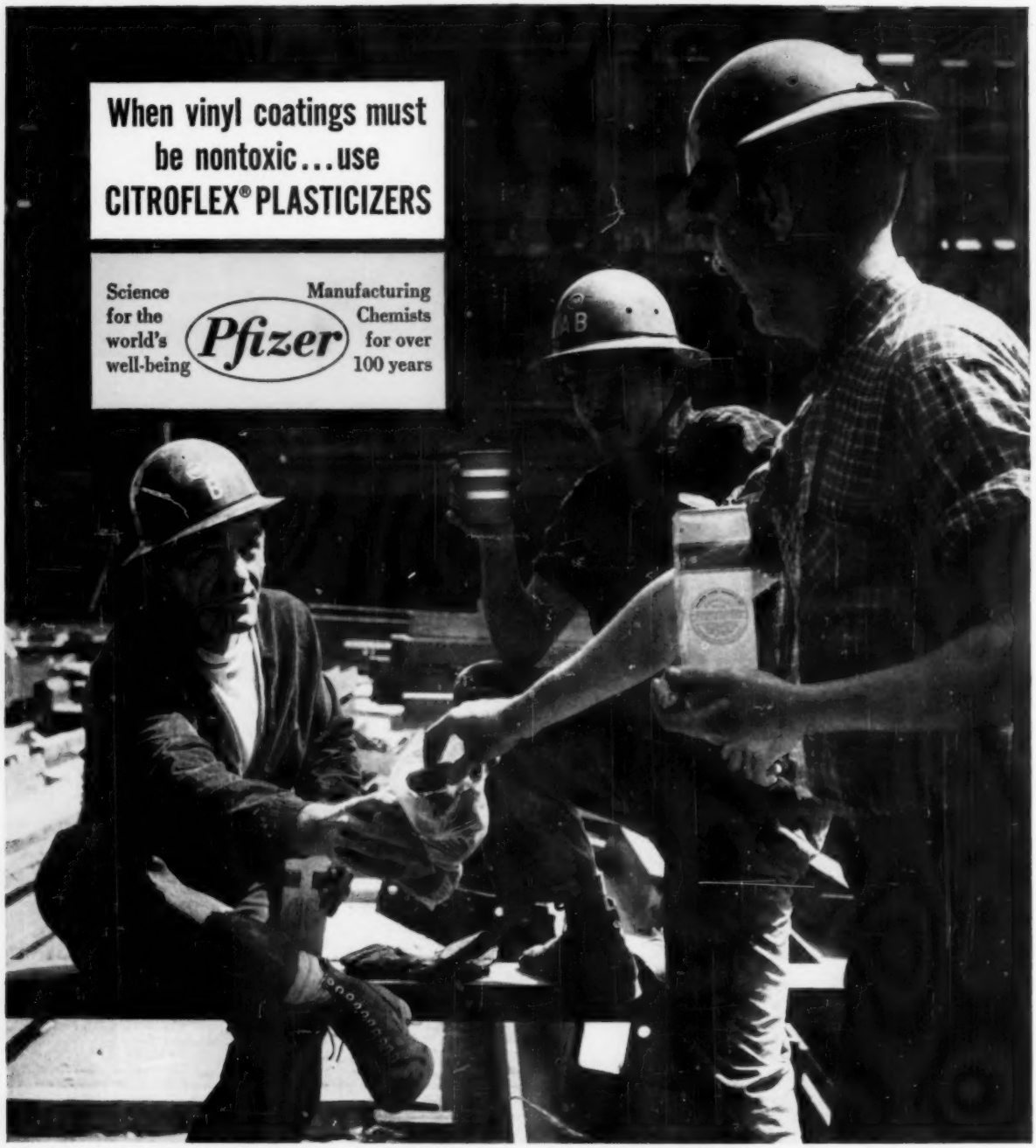
These properties, while important, were not the main reason for choosing Butyrate. Superior toughness was the big advantage Butyrate sheet offered over other plastic sign materials. Toughness was a "must" with Case, because the signs would have to endure considerable rough handling and abuse enroute to dealers, particularly those located in foreign countries. And even after reaching an overseas destination safely, there was still the possibility that inept handling by unskilled labor could result in breakage during installation. By specifying Butyrate, Case obtained maximum protection against breakage and costly, time-consuming replacements.

Another point in favor of Butyrate was its proved outdoor durability. Despite severe climates, hot or cold, the special weather-resistant formulation of Tenite Butyrate plastic used in these signs will keep them attractively bright for years.

Outdoor signs are a logical use for Tenite Butyrate, and sign men turn to this plastic when they need a tough, durable material. However, the applications for Tenite Butyrate cover a wide range of consumer and industrial uses. For more information on the performance advantages and easy-forming properties of Tenite Butyrate, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
BUTYRATE
an Eastman plastic

J. I. Case Co. signs are manufactured by Everbrite Electric Signs, Inc., 1440 N. Fourth St., Milwaukee 12, Wisc. Letter faces are vacuum-formed from extruded sheet of Tenite Butyrate plastic. Sheet is extruded by Southern Plastics Company, 408 Pendleton St., Columbia, South Carolina.


When vinyl coatings must be nontoxic...use CITROFLEX® PLASTICIZERS
Science for the world's well-being
Pfizer
Manufacturing Chemists for over 100 years

PLASTIC COATED CUPS • FOOD WRAPPINGS • FATTY FOOD CONTAINERS

● For many plastic coatings, packaging films and plastisols where toxicological safety is important Pfizer Citroflexes are the best possible plasticizers ...and surprisingly economical!

Odorless, as well as nontoxic, Pfizer Citroflex A-2 and A-4 have been accepted by the Food and Drug Administration for use in packaging *both fatty and non-fatty foods.*

CITROFLEX A-4 (Acetyl Tributyl Citrate) for polyvinyls—shows excellent results in plasticizing vinyl films for meat wrapping, vinyl coatings for food containers and hot drink cups, vinyl plastisols for bottle crown liners and food jar sealing rings.

CITROFLEX A-2 (Acetyl Triethyl Citrate) is especially suited for cellulosic packaging materials used for doughnuts, processed meats, etc.

When you need a *safe*, efficient, *economically-priced* plasticizer, take a look at the Pfizer CITROFLEXES.

CHAS. PFIZER & CO., INC. • *Chemical Sales Division* • 630 FLUSHING AVENUE, BROOKLYN 6, N.Y.

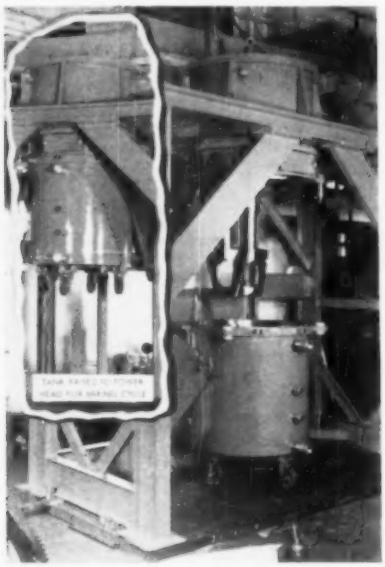
Branch Offices: Clifton, New Jersey • Chicago, Illinois • San Francisco, California • Vernon, California • Atlanta, Georgia • Dallas, Texas • Montreal, Canada

Planetary Mixer-Dispenser

The Beken planetary mixer-disperser, developed by Bramley Machinery Corp., features a 250-gallon, stainless steel, mixing chamber and specially designed, wedge-proof paddles, one of which rotates on its own axis in a planetary orbit. The heavy-duty, vertical mixer is only 14 feet tall and is powered with a four speed, 20-hp., explosion-proof motor.

The mixing chamber is jacketed around the periphery for cooling or heating, with an allowable internal working pressure of 50 psi. A separate hydraulic system raises the mixing chamber and holds it to the head to permit mixing under high vacuum. All bearings and gears are isolated to prevent contamination of the mixed materials.

Since the paddles intermesh, they create a continuous kneading and squeezing action. Should small lumps remain in the batch, this normal mixing can be reversed to provide a smearing action and a resultant uniform mass.



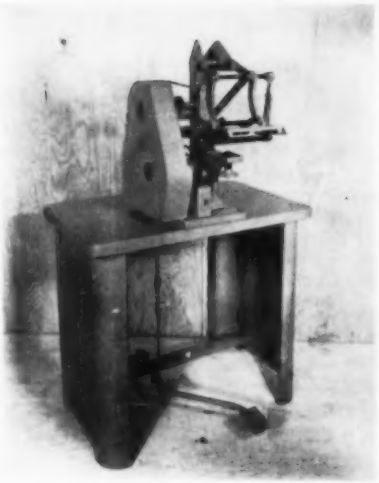
Beken Planetary Mixer.

Readers' Service Item 26

Pillow Pack Marker

Markem Machine Co. is offering Model 45A for marking individual, filled pillow packs at production speeds. The printing head accepts masterplate, rubber plate, and typebars. Easily interchanged, work-holding fixtures permit rapid changeover in marking several different types of items.

The bench-mounted marker, 13 by 23 by 26 inches, operates on a ¼-hp. motor. Maximum imprint area is 6-9/16 by 2-7/16 inches. Operating speed is 90 printing strokes per minute.



Markem 45A marking machine.

Readers' Service Item 27

Instrumentation for Extrusion

A pressure transducer specifically designed for extruders has been introduced by Dynamic Instrument Co., Inc. Called the Dynisco Model PT58, its function is to sense pressure fluctuations in the melt, so that steps can be taken to maintain constant pressure.

Features include: repeatability of 0.1%, diaphragm operating temperature of 750° F., and availability in a series to operate for pressure ranges of 0-1,000 to 0-10,000 psi. The transducers are normally supplied with a water cooling jacket which protects the strain gage sensing element from the high diaphragm temperatures. It is marketed in two stem lengths and mounts in a standard ½-20 NF threaded fitting, which is nearly standard for melt thermocouples and pressure gages. Approximate over-all length is 6¼ inches for the short stem, and 7¾ inches for the long stem.

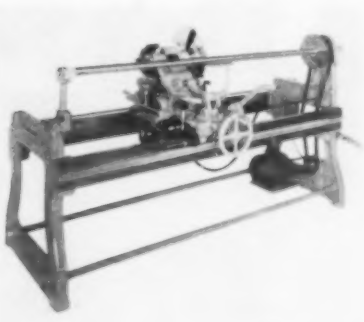
Short- and long-stemmed pressure transducers.

Readers' Service Item 28

Single-Knife Film Cutter

The Judelshon #360 V4 Super Duty Three Motor Cutter reportedly will slit rolls of polyethylene, nylon, Mylar, and polystyrene film in gages from 0.4 to 10 mils in about five minutes. Rolls as wide as 72 inches will be slit and trimmed, with a glass finish edge, to any desired width. The cutter will selvage trim as narrow as 1/16 inch.

The slitter will accommodate rolls with diameters up to 13 inches and cores of 1½ inches plus the thickness of the sleeves (usually three inches). It is 92 inches long, 48 inches wide, and 50 inches high. Since the edges are even and square, the trimmed sheet will be within the limits of a side-register control on printing or bag-making machinery.



Judelshon #360 V4 film slitter.

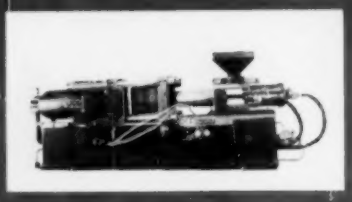
Readers' Service Item 29

Thumbscrew and slotted hose clamps.

Midget Hose Clamps

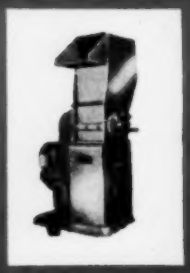
Ideal Corp. has announced the addition of two size 6 hose clamps to its line. Bands and housings are of 18-8 gage stainless steel insert. The clamps are available with a standard slotted headscrew (#5206) or a cadmium-plated thumbscrew (#5306). With outside clamp diameters ranging from 3/8 to 25/32 inch, the clamps will fit thin-walled, 3/8 to ½ inch hose.

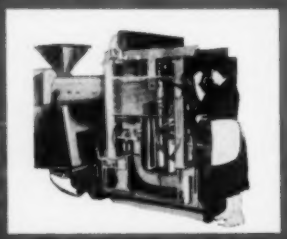
Readers' Service Item 30



DE MATTIA 8/6, 12/16 OZ. Injection Molding Machines

ACME Refrigeration Systems for Injection Molding Machines



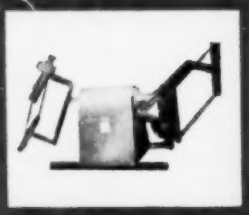


ACME Sy-Flo Machine Granulators in 1½, 2, 3 H.P.

BOSTON Double Head Bottle Blowing Machines 2 Molds Size: 26" x 14"

ACME

Plastics Machinery



ACME Grinders 3 to 20 Drums

ACME Grinder and Blenders ½ H.P.

MODEL BOSS Injection unit American Control

ACME MACHINERY & MFG. CO., INC.

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Plastics Applications

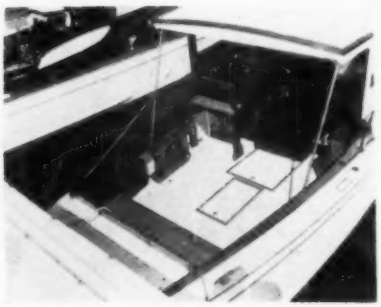
Write item numbers on Readers' Service Card (p. 97) to obtain more information.

TraveLodge complimentary shower cap.

Polyethylene Shower Cap

Complimentary polyethylene shower caps for tourists, designed and developed by Dobeckmun Co., are now being provided for guests of TraveLodges. The caps, which may also be used as a wrapping or carrying case, may contain printed advertisement.

Readers' Service Item 41



Cordo vinyl-coated deck covering.

Vinyl-Coated Deck Covering

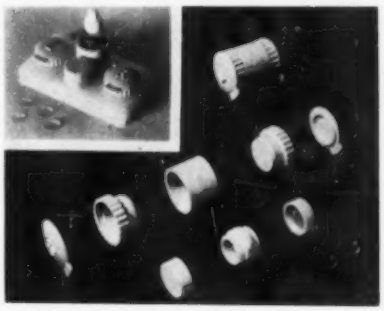
According to Cordo Chemical Corp., its deck covering of glass cloth coated with Union Carbide's Bakelite vinyl resins offers durable, non-skid flooring for boats, buses, and planes. Not only is the material reportedly resistant to abrasion, fire, and corrosion, but it is also more resilient than conventional non-skid flooring materials. A vinyl foam underlay is available for even greater resiliency. The embossed surface of the covering supplies non-skid properties.

The carpeting is approximately 0.15-inch thick and offers a warp tensile strength of 225 psi. and a fill tensile strength of 200 psi. (within 10%).

Readers' Service Item 42

Contact Lens Soaking Kit

Contact lens containers molded of Eastman's Tenite polyethylene come in a kit marketed by R. & F. Products Co., which also includes a supply of soaking solution and a small carrying case for extra lenses. The containers, molded by Mycro Tool & Die Co., are designed to permit the lenses to float freely and be completely hydrated. The containers, with molded identification markings, fit into a carrying ring for portability.



R. & F. contact lens kit.

Readers' Service Item 43

Polyurethane Pipe Insulator

Baldwin-Hill Rigid Foam Pipe Insulation, designed for application down to —300° F., is reported to have extremely low thermal conductivity. At 0° F., it has a K-factor of only 0.096 btu. per sq. ft., hr., °F.

Available in standard IPS sizes from ½ to 12 inch diameter, the polyurethane foam can be applied with ⅜- or ½-inch steel bands or with 16 galvanized iron tie wires and joints sealed with low-temperature mastics. With a density of three pounds per cubic foot at 75° F., its compressive strength is 50 psi.; flexural strength, 103 psi.; and tensile strength, 60

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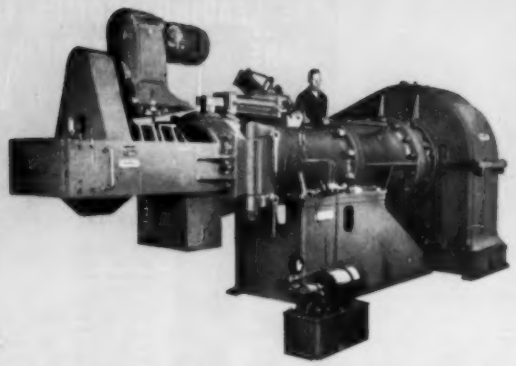
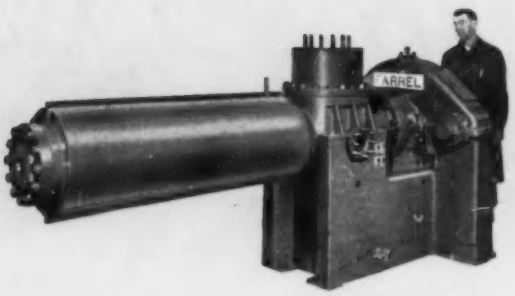
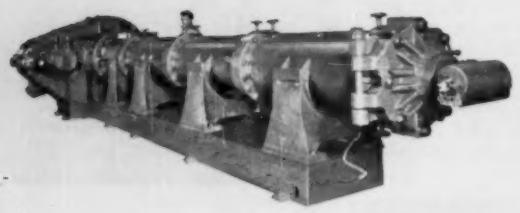


Newest design 18" pelletizer for use with high-speed, high-pressure Banbury mixer. Will deliver the batch of a size 11 Banbury in 45 seconds. New end-discharge type with variable-speed knife to regulate length of cut. Hopper has underfeed pusher to hasten feed to screw.



8" x 4½" extruder designed to work and cool hot polyethylene received from the processing line at 400 to 500° F. Delivers stock at a constant rate for pelletizing. Capable of a production rate of 1500 to 2500 lbs. per hour, depending on operating speed.



This 12" cold-fed extruder will continuously work polyethylene and deliver the stock in a strained condition through downward-discharge strip die at a rate of 3000 lbs. per hour. Driven by a 600-HP constant-speed motor, variations in speed are obtained with a hydraulic coupling.

How Farrel can help you get the exact extruder to fit the job

In recent years, Farrel has built a great many extrusion machines in a broad range of designs and sizes. This experience is the basis of the company's three-part program which can assist you in developing new products or new processing techniques involving the extrusion of rubber, plastics and other materials.

1. ENGINEERING ASSISTANCE — Farrel engineers are "on call" for consultation or engineering assistance in the development of unit operations or complete processing setups.

2. INDIVIDUALIZED EXTRUDER DESIGN — As any one of the hundreds of extruders built to date is adaptable in critical detail to a wide variety of requirements, and as special machines can be designed to meet unique conditions, developing the unit you need should seldom be difficult and never impossible.

3. PROCESS LABORATORY — A completely equipped laboratory, with a full complement of both experimental and factory-size machines, available for process testing your own materials.

Send for further details of this three-part program.

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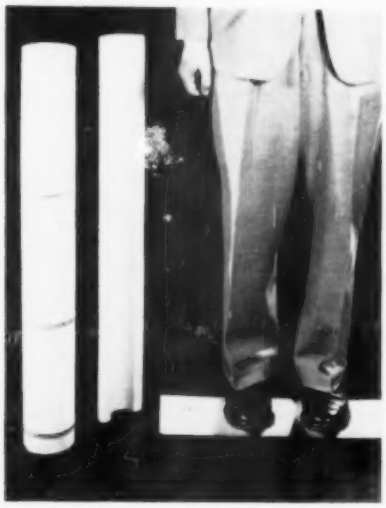
FARREL

FB-1155-A

psi. It thus resists damage to breakage in shipping and handling, as well as thermal and mechanical shock.



B-H Rigid Foam Pipe Insulation.

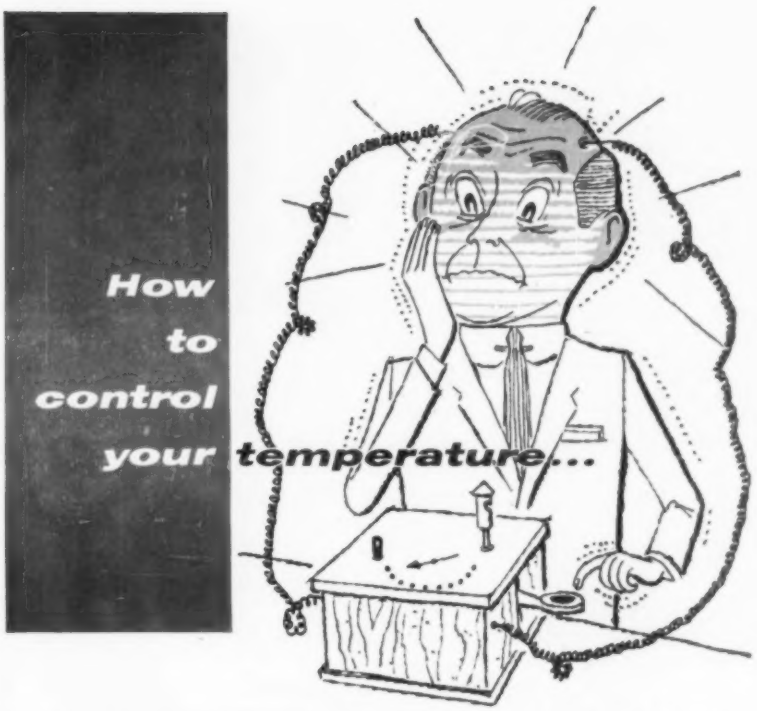
Readers' Service Item 44

Acetate Produce Containers

Packaging produce in blister packages is reported to increase physical volume and dollar sales. Collamer Produce Co. distributes onions and other produce in the blister packages molded from Celanese acetate by Syracuse Plastic Molders, and sells the packages to other distributors. According to Collamer, the packages eliminate 90% of the waste from spoilage due to handling, enhance the appearance of produce, and make cleaner and neater displays.

Collamer blister packages.

Readers' Service Item 45



Your personal temperature may soar when you see the advantages that others gain by improving control of temperature in operations like yours. But you can confidently control both types of temperature by using our consulting service and, if necessary, some of our instruments.

For we are specialists in temperature control. Our worldwide field force is constantly working with situations like yours, seeking waste and hidden potentials where "control is no problem." Working with your own people, chances are they'll find ways to boost your production...assure quality... reduce costs.

We provide such service without charge, to determine whether you really need our indicators or controllers or recorders, thermocouples and accessories. Chances are that you do; for our instruments soon save their cost in avoiding work-stoppage and reducing maintenance.

Stepless Controllers

Gardsman Model JSB (shown) provides closest control by controlling power to heaters through saturable core reactor, and permits manual operation as well. Full line provides for any application. All are tubeless, "solid-state" and proved in wide use. Phone your West consultant (see Yellow pages) or write Chicago office for Bulletin JSB or for COM digest-catalog of line.

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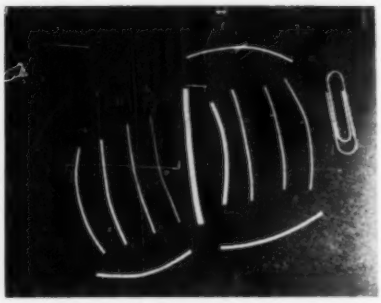
Teflon Spaghetti Sleeving

For use in electronic and electrical applications where high heat and corrosion or weathering conditions are encountered, Pennsylvania Fluorocarbon Co., Inc., offers a line of Teflon-paste extruded spaghetti slip-on sleeving. In sizes ranging from No. 30 to No. 0 AWG, the tubing is available in standard or thin wall form, from 0.001 (±.002) to 0.330 (±.004) inch hole diameter, with wall thickness of 0.004 to 0.020.

Three to six inch lengths of the small sheathings are used in microminiature electronic components for aircraft and missile control and guidance systems, telemetering systems, servomechanism relays, and computor wiring. Advantages claimed for the Teflon sleeving are that it won't melt or soften in contact with a soldering iron or gun; and that Teflon-encased copper or silver conductors can carry higher than rated current without overloading the insulation with heat.



Pennsylvania Fluorocarbon's Teflon tubing.

Readers' Service Item 46

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Today Williams offers a complete line of inorganic pigments and extenders for the plastics industry. All have color permanence and chemical stability. Here is a representative list of these products.

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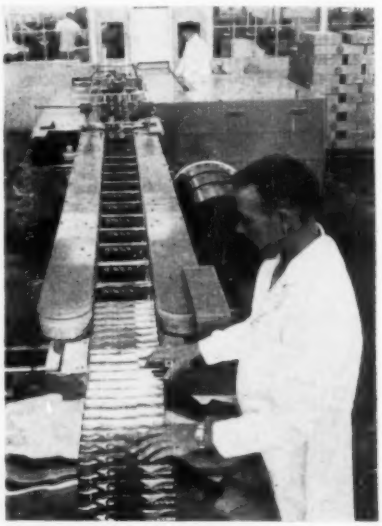
PVC & PVA Household Wraps

Although Reynolds Metals Co. has been making PVC and PVA films for some time, only recently have they brought them out as retail films under the trade name Reynolon.

The PVC film is cast onto a continuous belt, stretched biaxially, then wound. Orienting the film permits the use of thin gages which are competitive with most packaging films. Clarity is exceptional. It has high resistance to water and gas transmission, is sealable by heat and solvent, can be heat-shrunk for ripple-free, skin-tight packaging, and has unusual toughness. As a retail product, it is packed in standard 300-inch rolls and also in a 9-inch wide "sandwich-size" pack.

Water-soluble polyvinyl film dissolves in water in about one minute, faster in boiling water. Though not as yet accepted for food packaging, it has been tested experimentally for a couple of years with no adverse effects. A current application is the packaging of soap powders, where a number of measured quantities are individually packed in PVA film within the box. Not only does it eliminate measuring and waste, but the dissolved film increases the ability of the wash solution to hold dirt particles in suspension.



Reynolon PVC film wrap coming off packaging line.

Readers' Service Item 47

Book Reviews

"Fabricating with Formica." James M. O'Neill. Bruce Publishing Co., Milwaukee, Wis. Cloth, 7 by 10½ inches, 64 pages. Price, $3.50.

This how-to-do-it handbook will guide the amateur craftsman in constructing plastic laminates. Besides directing the handyman in the cutting, gluing or cementing, and trimming of Formica, it recommends materials and equipment. While the kitchen is the scene of most laminate application, bathroom vanitories and recreation room bars and furniture may also be constructed with the plastic laminate.

"1959—Kunststoffen Adresboek." N. V. Uitgeversbedrijf Reflex, Mathenesserlan 310, Rotterdam, Netherlands. Loose-leaf, paper cover, plastic back, 220 pages, 7-¾ by 10½ inches.

This directory for the Netherlands plastics industry was compiled in collaboration with the Plastics Institute at Delft by the N. V. Reflex, which also publishes the Netherlands plastics periodical, "Plastica." It is divided into seven sections and a supplement: (1). Netherlands manufacturers and importers of plastic materials, compounding ingredients, machinery, and finished goods, including details on products handled and banking connections; (2). Names and addresses of foreign firms represented in the Netherlands and their Netherlands agents; (3). Buyers' guides for basic materials, chemicals, other ingredients, and semi-manufacturers; (4). Finished plastic articles; (5). Machinery, accessories, and molds; (6). Domestic and foreign periodicals in plastics and allied fields; and (7). Netherlands and foreign plastics research institutes. The supplement corrects errata.

"Processing of Thermoplastic Materials." Edited by Ernest C. Bernhardt for The Society of Plastics Engineers, Inc. Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. Cloth, 6¼ by 9¼ inches, 690 pages. Price, $18.00 (members, $14.40).

This handbook and text reviews the engineering fundamentals on which the design of plastics processing equipment is based, and demonstrates the application of these concepts in the analysis of thermoplastics processing problems. Representing contributions by 19 technical authorities, the volume emphasizes the theoretical, scientific foundation of plastics engineering.

The book is divided into three large sections: fundamentals, applications, and processing properties. The first is concerned with flow behavior, heat transfer and thermodynamics, and mixing and dispersing. The second discusses the theories on which equipment for extrusion, injection molding, calendering, sheet forming, blow molding, mixing and dispersing, and sealing and welding are constructed; while the third graphically represents viscous and thermal properties of selected plastic resins.

Neither processes involving major chemical transformations and reactions nor chemical changes which may accompany processing operations are discussed.

"Japan Plastics Industry Annual, 1959." Plastics Age Co., Ltd., Osaka and Tokyo, Japan. Plastic-coated paper, 238 pages, 9½ by 11½ inches. Price, $5.00.

Although the Japanese plastics industry is comparatively new, it has grown remarkably and now ranks fourth in world production. Figures on this development

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News from Abroad

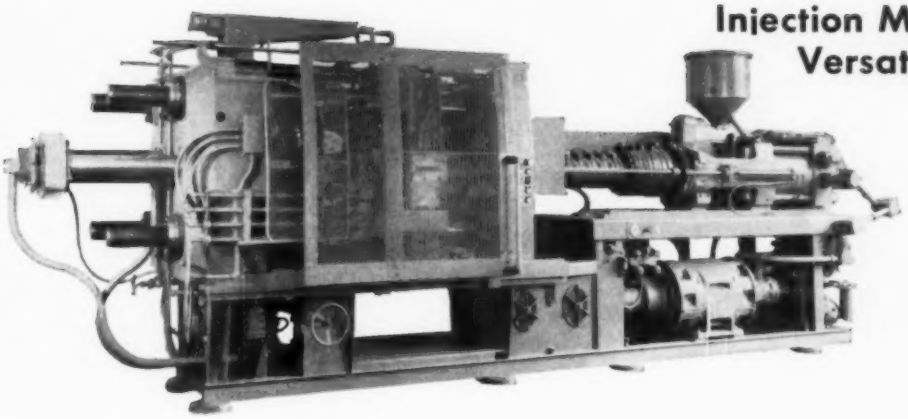
(Cont'd. from page 65)

Resnit is the name of a British resin-impregnated knitted fabric designed for use in the reinforced plastics field. Available as semi-rigid sheeting, it is extensible during forming. Pressures used are normally in the range of 100-500 psi., along with temperatures around 160° C. Press cycle times are 1½-2 minutes, but can be speeded to six seconds by shock curing. Currently used grades are made cellulose fibers and phenolic resin, but these can be varied to suit the end uses of the laminates.

British Celanese, Ltd., is producing polypropylene yarns at the Conventry factory. A spinning process, developed by **Courtaulds, Ltd.,** is being used.

Furamel 201 is the designation of a new furan resin developed by the French firm, **Usines de Melle.** The material is a pre-polymer, hardenable without pressure. It is supplied as an off-black paste with a density of 1.23.

S.A. Phenix Works' Aluminum Skinplate (PVC-aluminum laminate) is being used in construction work at the airport of Melsbroek, near Brussels, Belgium. Sheets are available measuring one by two meters and in 30 different colors. They can be spot-welded at the metal surfaces.



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introduce this annual. About half the publication is devoted to English and a few Spanish catalogs. Index charts designed to aid identification of a particular firm by its products, and vice versa, are provided. The charts are cross-referenced to other sections of the annual.

A Graphic Review illustrates various Japanese products. Of special interest is a statistical review of the Japanese plastics industry which details progress achieved in various plastics and tabulates monthly figures of total output, manufacturers' consumption and deliveries, and stocks during 1958. Finally, an alphabetical classified directory of manufacturers and dealers in materials and equipment, as well as processers, lists addresses of companies' main and branch offices, plants, names of representatives, and information on principal products.

"Moulage par Compression et Moulage par Transfert de Resines Thermodurcissables." (Compression and Transfer Molding of Thermosetting Resins.) Translated from the Italian by Jean Delorme. Editions Amphora, Paris, France. Paper, 6 by 9½ inches, 336 pages. Price, 3,000 francs plus postage.

The original Italian work, "Lo Stampaggio delle Resine Termoindurenti," was compiled by the technical service of Montecatini Co. of Milan for the company's plastics sales department, development and propaganda bureau. A review of the general concepts of molding is followed by a discussion of design problems, such as intended use, appearance, cost, weight, strength, ribs, undercuts, taper, and inserts. About two-thirds of the book is devoted to compression molding, including an especially long chapter on practical types of molds. Transfer molding and molds are dealt with in the final chapters. More than 350 line drawings illustrate the various techniques.

"Modern Materials: Advances in Development and Applications." Volume 1. Edited by Henry H. Hausner. Academic Press Inc., 111 Fifth Ave., New York 2, N. Y. Cloth, 6¼ by 9¼ inches, 402 pages. Price, $12.50.

The first in a projected series providing information on new developments and materials, this volume surveys several categories. Included are wood, synthetic rubbers and plastics, fibers, high voltage insulation papers, special glasses for nuclear engineering applications, ceramics, germanium, silicon, and zirconium.

Although the book serves as an introduction to many of the topics, it has not been written for the non-technical reader. It is useful for acquainting the technical man with subjects outside his specialty.

"Laminated Plastics." D. J. Duffin. Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. Cloth, 5 by 7½ inches. 254 pages. Price, $5.75.

Laminated plastics, those solid, dense, almost homogeneous materials produced by fusing thermosetting resin-impregnated fillers by heat and pressure, may be classified, according to the means of processing as high pressure or low pressure (reinforced plastics) laminates. The former are those processed at pressures above 1,000 psi.

In the making of high pressure laminates, the filler is impregnated, dried, and cut into sheets before being sandwiched, under heat and pressure, with other layers. Low pressure laminates, on the other hand, may be formed by press molding, hand lay-up, or contact molding. The first utilizes positive pressure as well as the chemical action of resins and catalysts. Although vacuum bag molding may use vacuum or positive pressure, other types of hand lay-up require neither. Contact molding, the most widely used reinforced plastics molding method, requires no pressure.

Phenolics, melamines, silicones, epoxies, polyesters, fluorocarbons, and acrylics are common thermosetting resins used in conjunction with fillers such as paper, cotton, asbestos, and glass fiber. Properties and characteristics of these resins and fillers are discussed in detail.

Other chapters include machining laminates, applications and end products, and heat-resistant and special laminates.

Abstracts of Important Articles

Materials

"Ultraviolet Absorbers for Plastics," R. A. Coleman and J. A. Weicksel, *Modern Plastics*, 36, 12, 117 (Aug. 1959).

A discussion of U-V absorbers and their applications in plastics.

"Today's Approaches to Vinyl Stabilization," R. A. Buckley, *Western Plastics*, 6, 9, 29 (Sept. 1959).

Current stabilizations are shown to depend on end-product type requirements.

"Stabilization of Mixtures Containing Polyvinyl Chloride," C. H. Fuchsman, *SPE J.*, 15, 9, 787 (Sept. 1959).

PVC discoloration is shown to relate to the presence of zinc and cadmium.

"Creep Behavior of Transparent Plastics at Elevated Temperatures," F. L. McCrackin and C. F. Bersch. *SPE J.*, 15, 9, 791 (Sept. 1959).

Results are given for experiments measuring creep and elongation of plastics exposed to temperature differentials and biaxial stresses.

"High Molecular Weight Plasticizers for PVC," A. Hill, *Brit. Plastics*, 32, 2, 74 (Feb. 1959).

The high molecular-weight plasticizers dealt with are polyesters and epoxidized unsaturated glycerides. For comparison, simple di- and tri-ester plasticizers of low molecular-weight also are considered. The former are divided into four groups according to viscosity and molecular weight, and their chemical structure is discussed, as well as compounding, compatibility, volatility, and mechanical and electrical properties. Migration, as well as extraction by liquids, the controlling factors involved here, and results obtained receive special attention.

"Polyethylene—Mechanisms of Fracture," P. L. Clegg, S. Turner and P. I. Vincent, *Plastics (London)*, 24, 256, 31 (Jan. 1959).

The authors find there is need to unify the various failure mechanisms either by examining and classifying them or by attempting to explain them in terms of polymer structure, as well as for useful correlation between service life and simple laboratory experiments. They report on a detailed study of types tensile, impact, low-temperature, and film failures, and also long-term failure under environmental stress-cracking, stress, and high-temperatures and describe the tests employed. They advocate a new approach to testing polyethylene since many tests now in use give results which have far less meaning than many people think they have.

"How the New Propellents Affect Plastics and Elastomers," R. E. Mowers, *Materials Design Eng.*, 50, 3, 89 (Sept.)

Data are given on strengths, elongation, hardness, and swelling of various plastics as affected by exposure to the new, storable, missile propellents.

"Gas Transmission by Plastics Films," W. E. Brown and W. J. Sauber, *Modern Plastics*, 36, 12, 107 (Aug. 1959).

A simple test apparatus is described, and typical transmission rate data are given.

"Progress in Five Years of Research in Stereospecific Polymerization," Giulio Natta, *SPE J.*, 15, 5, 373 (May 1959).

A 15th ANTEC paper reviewing work in isotactic polymers.

"Determining Flow Behavior of Thermoset Molding Compounds with Flow-Testing Apparatus. Introduction to Draft Standard DIN 53478," C. M. von Meysenbug, *Kunstoffe*, 49, 3, 130 (March 1959).

The Plastics and Materials Testing Branches of the German Standards Committee have collaborated in drafting standard specifications for a test on the flow behavior of thermosetting molding compounds in the form of powders, granules, fibers, and chips. The test is an adaptation of the Rossi-Peakes Flow Test, having a far-wider field of application. The proposed test specifications are reproduced in full. (In German.)

"Friction in Plastics," G. Lanzavecchia, *Materie Plastiche*, 23, 11, 884 (No.v 1957).

A rapid and simple review of the research that has been carried out on friction in macromolecular substances, referring to the literature published in Europe and America from 1929-1956. Differences between friction in metals and plastics, methods of determining friction, and the factors influencing friction (as surface condition, creep, temperature, lubricants, chemical and molecular structure fillers) are covered. (In Italian.)

"Effect of Weathering on Color of Polyester/Glass Laminates," K. A. Scott, *Brit. Plastics*, 32, 3, 112 (March 1959).

The color of pigmented polyester/glass laminates is not affected by immersion in boiling water for 18 hours, experiments showed. However, parallel tests on identical mixes containing also one of five different fillers indicated that certain fillers tend to cause fading under the same conditions.

"Some Experiments on the Flow Properties of Polyethylenes," R. W. Hogg, *Plastics (London)*, 24, 257, 69 (Feb. 1959).

The study of the melt/flow behavior of polyethylenes helps to provide valuable insights into the basic character of the polymer molecule. Results are presented of established tests carried out on 13 samples of polyethylene, including low and higher-density Alkathenes, and higher-density Ziegler and Phillips materials. Explanations are suggested for certain differences in flow behavior of the materials currently obtained by the various polymerization processes, and for some apparent anomalies in the comparison of laboratory and operational results.

"Radiation Initiated Graft Polymerization," R. Roberts, *Rubber & Plastics Age*, 40, 2, 145 (Feb. 1959).

Work on graft copolymerization in America and in Britain has led to the production of a number of promising new materials. At Wantage Radiation Laboratory a graft copolymer of acrylonitrile and polydimethylsiloxane was obtained which had greatly increased oil-resistance. Intensive studies have also been carried out on polymer emulsion systems (e.g., polybutyl methacrylate/vinyl acetate). It is hoped that the presence of the butylmethacrylate will act as an internal plasticizer for the polyvinyl acetate. Investigations are now in progress on the modification of surface properties of polyethylene fibers, nylon, Orlon, and Terylene with a view towards reducing static problems.

In the reference system used, the first number following the magazine name is the volume number, the second is the issue number (if any), and the third is the first page on which the abstracted article appears in that magazine.

Request for copies, reprints, or further information on any article abstracted in this department should be addressed to the publisher of the magazine where the article appeared. A complete listing of the publishers and addresses of these magazines is printed here quarterly.

The next complete listing will appear in February. The last listing appeared in the October issue.

Equipment

"High Temperature Mechanical Properties of Unfilled and Carbon-black Loaded Irradiated Polyethylene," S. H. Pinner, *Plastics (London)*, 24, 257, 74, (Feb. 1959).

Commercially-available tensometers cannot be operated conveniently at 150° C., the temperature suitable for measuring mechanical properties of irradiated polyethylene. Hence, a lightweight, high temperature tensometer was designed and is described. Preliminary data on unfilled and carbon-black filled irradiated polyethylene, obtained in the course of calibrating the high-temperature tensometer are presented and discussed to illustrate the potential usefulness of the device.

"Multi-cavity Injection Mold with Internal Sprue and Hot runners for Screw Joints," H. Gastrow, *Kunststoffe*, 49, 3, 149 (March 1959).

After discussing the problems involved in designing hot-runner molds, the author describes a mold with which eight screw joints can be produced at one time without externally-visible gate marks. Mention also is made of the production of thick-walled or large moldings by the hot-runner method. (In German.)

Applications

"New Developments in Adhesives for Plastics," Bernard Gould, *Plastics Industry*, 17, 4, 22 (April 1959).

A review of some new development adhesives.

"Adhesive Bonding," J. C. Merriam, *Materials Design Eng.*, 50, 3, 113 (Sept. 1959).

How adhesives are used to bond different products.

"Symposium on Plastics in Agriculture," *Ind. Plastiques Mod.*, 11, 3, 4, (March 1959).

At a Symposium on Plastics in Agriculture, held February 5, 1959, in Paris, ten papers were presented: "Tilts of Polyethylene," J. Leurteux; "PVC Film for Ensilage," M. Doligez; "PVC Film for Water- and Gas-Tight Applications," G. Janny; "Polyethylene Film for Watertight Structures," J. Leurteux; "Glass Cloth for Checking the Shifting of Soil," A. de Coincy; "Experiments in Semi-forcing under Polyethylene," G. M. Bouger; "Study of Thermal Insulation by Means of Transparent Plastic Film." R. Algrain; "Building a Greenhouse of Rilsan Film" F. D'Ogny; "Greenhouse of Rigid PVC (Lucoflex T)," J. Bost; and "Cultivating Plants in Pots of Rigid PVC," J. Bost. (In French.)

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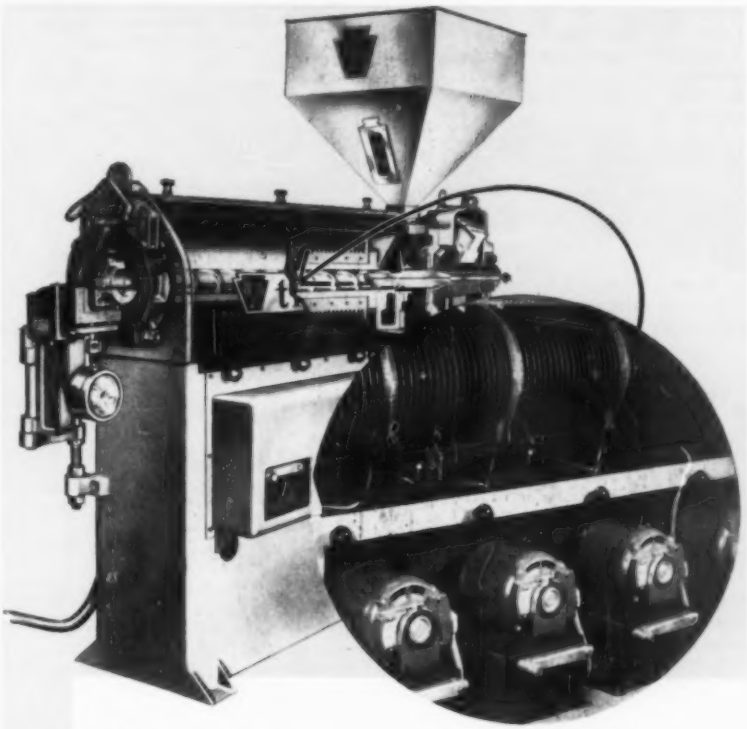

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Patent Digest

Materials

Asphalt Composition Containing Polyethylene. No. 2,871,212. C. H. Thayer, Wallingford, Pa. (to Sun Oil Co., Philadelphia, Pa.).

Adding polyethylene increases the penetration rate of asphalt.

Solid Polymers of Epichlorohydrin. No. 2,871,219. J. M. Baggett, Freeport, and M. E. Pruitt, Lake Jackson, Tex. (to Dow Chemical Co., Midland, Mich.).

Epichlorohydrin is stabilized by incorporating a phenolic antioxidant.

Epoxy Resins Cured with Dianhydride of Tetracarboxylic Acids. No. 2,871,221 R. G. Shepherd, Jr., Weston, and E. C Dearborn, Boston, Mass. (to U. S. Testing Co., Inc., Hoboken, N. J.).

A polyepoxy compound, dicarboxylic acid anhydride, and tetracarboxylic acid anhydride are cured by heat.

Epoxidation Process. No. 2,870,171 C. M. Gable, Lafayette, Calif. (to Shell Development Co., New York, N. Y.).

An ethylenic compound is reacted with hydrogen peroxide and a tungstic acid.

Curing of Epoxy Resins. No. 2,868,767. H. A. Cyba, Chicago, and R. B. Thompson, Hinsdale, Ill. (to Universal Oil Products Co., Des Plaines, Ill.).

An epoxy resin formed by the reaction of a dihydric phenol and a 1,2-epoxy compound selected from the group consisting of epichlorhydrin and polyglycidyl ethers is cured by heating it with a condensation product of an N,N-dialkyl-alkanolamine and polycarboxylic acid, anhydride, or ester.

Polyalkylene Oxide Resins. No. 2,870,101. D. G. Stewart, Epsom, England (to Shell Development Co., New York, N. Y.).

A vic-epoxy hydrocarbon, free of nonaromatic unsaturation, is polymerized in the presence of a complex catalyst consisting of two metals, alkyls and alkoxies, a halogen, and hydrogen.

Polymerization of Epoxides. No. 2,866,761. F. N. Hill, S. Charleston and J. T. Fitzpatrick, Charleston, W. Va. (to Union Carbide Corp.).

Alkylene oxide is contacted with a catalytic quantity of a metal chelate compound to produce poly (alkylene oxide.).

Printable Polyethylene Film. No. 2,870,043. L. E. Wolinski, Buffalo, N. Y. (to E. I. du Pont de Nemours and Co., Wilmington, Del.).

Polyethylene film surface is uniformly coated with a composition comprising 0.4-3.0 mgs. per sq. ft. surface of dimethyl silicone oil, and 0.8-2.5 mgs. per sq. ft. surface of a water-soluble alkyl aryl polyglycol ether.

Coated Polymeric Thermoplastic Dielectric Film. No. 2,870,044. P. S. Blatz, Buffalo, N. Y. (to E. I. du Pont de Nemours and Co., Wilmington, Del.).

A polymeric, thermoplastic, dielectric base film has an adherent, continuous, cured coating of either a phenol-formaldehyde or alkyd resin and a titanium organic compound.

Process for Preparing Resins of Polysubstituted Benzenes. No. 2,870,098. R. W. Martin, Lafayette, and F. E. Condo, El Cerrito, Calif. (to Shell Development Co., New York, N. Y.).

A bis(chloromethyl)tetra-alkyl benzene and a tetra-alkyl benzene, each having 1-4 saturated aliphatic carbon atoms per alkyl group, are combined in the presence of an inert solvent at 100°-250° C. to produce a benzene polymer with substituted saturated aliphatic radicals.

Process for Polymerizing Ethylenic Organic Compounds with Redox System Catalysts in the Presence of Betaine Derivatives. No. 2,870,118. E. Bäder, Hanau (Main), and O. Schweitzer, Konigstein (Taunus), Germany (to Deutsche Gold- und Silber-Scheidanstalt vormals Roessler, Frankfurt am Main, Germany).

A polymerizable mass containing a catalytic amount of a Redox system catalyst with at least one peroxide and one organic sulfur containing compound is polymerized in the presence of a soluble betaine derivative.

Production of Polymers of Epoxide Compounds. No. 2,870,100. D. G. Stewart, Flixton, Manchester, D. Y. Waddan, Manchester, and E. T. Borrows, Bowden, England (to Shell Development Corp., New York, N. Y.).

A vic-epoxy hydrocarbon, free of nonaromatic unsaturation, is polymerized in the presence of 0.1-2.0% catalyst consisting of a group II or III metal, a hydrocarbon radical of 1-10 carbon atoms, and a member of the class consisting of a hydrogen atom, halogen atom, hydrocarbon radical of 1-10 atoms, alkoxy radical, and secondary amino radical.

Printed copies of patents are available from the Commissioner of Patents, Washington 25, D. C. Prices, 25c each.
—The Editor

Chlorosulfonated Polyethylene Composition Containing Sulfurized Tall Oil. No. 2,870,103. E. O. Ridgway, Scotch Plains, and N. A. Perry, Hamilton Square, N.J. (to Ridbo Laboratories, Inc., Trenton, N. J.).

The thermal reaction product of tall oil and sulfur, the sulfur 1-25% by weight of the oil, is combined with chlorosulfonated polyethylene to form a rubber composition adapted to be worked to a desired shape.

Novel Silica Products and Silicone Rubber Containing Same Coated Silica Aerogel, Silicone Rubber Reinforced Therewith and Method of Making. No. 2,870,108. R. F. Nickerson, Marblehead, Mass. (to Monsanto Chemical Co., St. Louis, Mo.).

To obtain non-organophilic, hydrophilic to partially hydrophobic silica aerogels, silica aerogel particles with an acid number of 0.3-3 and an ultimate particle size of 5-40 millimicrons are comminuted in an air attrition mill and concurrently sprayed with droplets containing tetraethyl orthosilicate until the particles have an aggregate size between 0.01-15 microns. The silicate is 3-20% the weight of the dry silica aerogel particles.

Production of Polymers of Epoxide Compounds. No. 2,870,099. E. T. Borrows, Bowdon, and D. G. Stewart, Flixton, Manchester, England (to Shell Development Co., New York, N. Y.).

A vic-epoxy hydrocarbon, free of nonaromatic unsaturation, is polymerized in the presence of 0.1-2.0% catalyst consisting of a group II or III metal and an alkoxy radical.

Process for Preparing Polyurethane Foams Employing Tertiary Amine Catalysts. No. 2,866,762. F. Brochhagen, Odenthal Bezirk Koln, and K. E. Müller, Leverkusen-Bayerwerk, Germany (to Farbenfabriken Bayer A. G., Leverkusen, Germany).

An organic diisocyanate is added to a mixture of water, a hydroxyl polyester prepared by the esterification of a dicarboxylic acid with a polyhydric alcohol, and an activator containing at least one tertiary amino group and reactive hydrogen group. After the mixture is stirred, a foamed plastic forms.

Heat-Stress Cracking Resistance of Thermoplastic Filamentous Articles. No. 2,867,848. R. M. McGlamery, Bartlesville, Okla. (to Phillips Petroleum Co.).

A filamentous article of crystalline ethylene polymer having a crystallinity at 25° C. of at least 80%, a density of at least

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1½	21:1	31½	30-40	6	1750	2	1	3	11,300	50 x 25	1750	3
2½	15:1	38	70-95	6	2500	2	1	3	71,100	66 x 41	3200	10-15
	21:1	53⅜	100-130	9	2500	3	1	4	71,100	81 x 41	3500	10-15
	24:1	60¼	110-150	10	2500	3	1	4	71,100	88 x 41	3800	10-15
	30:1	75⅛	120-170	14	2500	4	1	5	71,100	100 x 41	4000	10-15
3½	21:1	73½	210-280	13	2500	3	1	4	221,900	111 x 70	5000	25-40
4½	15:1	60⅜	220-300	9	2500	4	1		221,900	105 x 70	5350	40-50
	21:1	93½	300-420	16	3200	4	1	5	221,900	138 x 70	6000	40-60
	24:1	108¼	350-480	19	3200	4	1	5	221,900	153 x 70	7000	40-75
	30:1	135	410-540	24	3200	5	1	6	221,900	180 x 70	8000	40-75
6	15:1	89⅛	400-530	10	6000	4	1	5	279,500	148 x 82	7200	50-60
	21:1	125¾	550-750	14	6000	4	1	5	279,500	183 x 82	8000	50-100
	24:1	144½	630-860	20	6000	5	1	6	279,500	203 x 82	8500	50-150
	30:1	180¼	700-950	26	6000	6	1	7	279,500	236 x 82	9000	50-200
8	15:1	112	700-950	15	8000	4	1	5	370,000	179 x 100	8200	75-150
	21:1	168	1000-1300	22	8000	5	1	6	370,000	234 x 100	9000	75-200
	24:1	192	1100-1500	26	8000	5	1	6	370,000	258 x 100	10,000	125-250
	30:1	240	1200-1700	34	8000	6	1	7	370,000	306 x 100	12,000	150-300
10	21:1	210	1500-2100	30	8500	5	1	6	465,000	310 x 120	13,000	150-300
12	7:1	84	1000-1500	9	10,000	2	1	3	525,000	206 x 125	11,500	200-300
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CALENDAR of COMING EVENTS

January 12-15
SPE Chicago Section ANTEC. Conrad Hilton Hotel, Chicago, Ill.

January 26-27
Society of Vacuum Coaters. Biltmore Hotel, New York, N. Y.

February 1
American Society of Heating, Refrigeration, and Air-Conditioning Engineers. SPI Symposium on Plastics in Domestic Refrigeration: Improving Performance and Customer Acceptance of Plastics in Domestic Refrigeration Appliances. Baker Hotel, Dallas, Tex.

February 2-4
SPI Reinforced Plastics Division Conference. Edgewater Beach Hotel, Chicago, Ill.

February 10
SPE Newark Section. Military Park Hotel, Newark, N. J.

February 17
SPE New York Section. Governor Clinton Hotel, New York, N. Y.

March 30-31
Plastics Institute. Conference on Polymeric Progress. William Beveridge Hall, London University, London, England.

April 20
SPE North Texas Section RETEC. Plastics in the Petroleum and Chemical Industries. Hotel Texas, Fort Worth, Tex.

May 20-31
Norsk Plastforening. International Plastics Exhibition. Oslo, Norway.

Current Market Prices

Price Changes and Additions

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Cyanamid chrome yellow and oranges	lb.	$0.35	
Lubricants			
Dow Corning 8, 35, 35A, 35B, 36 emulsions	lb.	1.15 /	1.69
200 fluid	lb.	2.90 /	6.00
Mold release B	gal.	5.00 /	9.00
Plasticizers			
Eastman dibutyl phthalate	lb.	.26 /	.30
Di-(2 ethyl hexyl) phthalate	lb.	.27 /	.31
Di-isobutyl phthalate	lb.	.255 /	.295
Triacetin	lb.	.37 /	.41

Domestic Production and Sales of Plastics and Resin Material, July and August, 1959

Following are the partly estimated and revised statistics for the domestic production and sale of plastics and resinous material during the months of July and August, 1959. Units listed are in pounds, dry basis unless otherwise specified. Data on alkyds and rosin modifications have not been included since their use is primarily limited to the protective coating industry.

	July, 1959		August, 1959	
	Production	Sales	Production	Sales
Cellulose Plastics:[1]				
Cellulose acetate and mixed ester:				
Sheets, under 0.003 gage	1,859,056	1,625,157	1,545,631	1,528,429
Sheets, 0.003 gage and over	1,919,511	1,695,432	1,840,966	1,635,993
All other sheets, rods, and tubes (including other cellulose plastics)	658,669	764,182	699,672	841,539
Molding and extrusion materials (including other cellulose plastics)	8,011,880	7,784,708	8,689,694	8,457,468
Nitrocellulose sheets, rods, and tubes	249,769	136,731	238,145	126,931
TOTAL	12,698,885	12,006,210	13,014,108	12,590,360
Phenolic and Other Tar-Acid Resins:				
Molding materials[2]	16,518,133	14,713,284	18,236,957	17,288,848
Bonding and adhesive resins for—				
Laminating (except plywood)	5,739,690	3,950,209	6,675,855	4,706,369
Coated and bonded abrasives	913,508	891,690	1,314,641	1,137,811
Friction materials (brake limings, clutch facings, and similar materials)	1,260,522	1,241,603	1,737,303	1,406,117
Thermal insulation (fiber glass, rock wool)	3,516,647	3,723,250	4,073,237	3,689,867
Plywood	4,247,810	3,631,018	5,225,138	4,540,335
All other bonding and adhesive uses	4,331,592	4,761,223	4,859,364	4,695,258
Protective-coating resins unmodified and modified except by rosin	2,033,279	1,832,798	2,427,203	1,987,149
Resins for all other uses	3,423,981	3,153,877	3,652,729	3,371,232
TOTAL	41,985,162	37,898,952	48,202,427	42,822,986
Urea and Melamine Resins:				
Textile-treating and textile-coating resins	2,045,456	2,228,843	2,915,913	2,400,850
Paper-treating and paper-coating resins	2,083,695	2,131,647	2,549,632	2,390,760
Bonding and adhesive resins for—				
Laminating	2,574,860	2,589,856	2,980,112	2,395,596
Plywood	8,887,517	8,499,417	7,729,464	9,308,607
All other bonding and adhesive uses	1,477,607	1,586,887	1,748,183	1,622,188
Protective-coating resins, straight and modified	3,135,403	2,336,313	3,168,173	2,286,718
Resins for all other uses, including molding	6,400,823	7,708,941	10,400,484	10,245,977
TOTAL	26,605,361	28,081,904	30,491,961	30,650,696
Styrene Resins:				
Molding and extrusion materials:				
Straight polystrene	21,047,080	17,886,346	20,879,639	21,038,657
All other	27,229,030	22,592,003	30,481,615	25,456,533
Protective-coatings	5,969,763	5,377,116	5,597,488	4,849,271
Textile and paper treating and coating resins	5,190,165	3,869,483	5,112,461	3,925,000
All other uses	12,256,843	14,850,141	12,736,104	14,108,414
TOTAL	71,692,881	48,477,269	74,807,307	69,377,875
Vinyl and Vinyl Chloride Resins:[3]				
Polyvinyl chloride and copolymer resins (50% or more PVC) for—				
Film (resin content)		6,544,709		7,073,586
Sheeting (resin content)		9,328,606		10,750,191
Molding and extrusion (resin content)		22,645,415		25,069,040
Textile and paper treating and coating (resin content)[3]		5,263,224		5,683,053
Flooring (resin content)		12,155,991		12,867,271
Protective coating (resin content)		2,849,976		2,601,946
All other uses (resin content)		7,340,004		7,940,358
All other vinyl resins for—				
Adhesives (resin content)		4,853,122		4,915,042
Protective coatings (resin content)		2,697,234		2,402,014
All other uses (resin content)		10,586,970		9,977,471
TOTAL	94,271,961	84,265,251	98,765,712	89,279,972
Coumarone-Indene and Petroleum Polymer Resins	23,121,361	22,648,632	23,798,208	24,058,312
Polyester Resins:				
For reinforced plastics	9,828,173	9,662,426	10,022,499	8,281,221
For all other uses	1,858,099	1,691,777	1,469,733	1,415,831
TOTAL	11,686,272	11,354,203	11,492,232	9,677,052
Polyethylene Resins:				
For film and sheeting		28,002,143		27,758,326
Molding materials		15,731,056		18,880,335
Extrusion materials		11,347,009		13,309,109
For all other uses		31,695,288		31,352,593
TOTAL	100,476,520	86,775,496	103,097,099	91,300,363
Epoxy Resins:				
For protective coatings		1,763,692		1,748,316
For all other uses		2,144,393		2,167,753
TOTAL	3,413,246	3,908,085	4,461,480	3,916,069
Miscellaneous Synthetic Plastics and Resin Materials, Including Silicone Resins	19,020,489	16,371,699	20,684,551	16,532,793
GRAND TOTALS	404,972,138	351,787,701	428,815,085	390,206,478

[1] Includes fillers, lasticizers, and extenders.
[2] Production statistics by uses are not representative, as end use may not be known at time of manufacture.
[3] Includes data for spreader and calendering-type resins.
SOURCE: United States Tariff Commission, Chemical Division.

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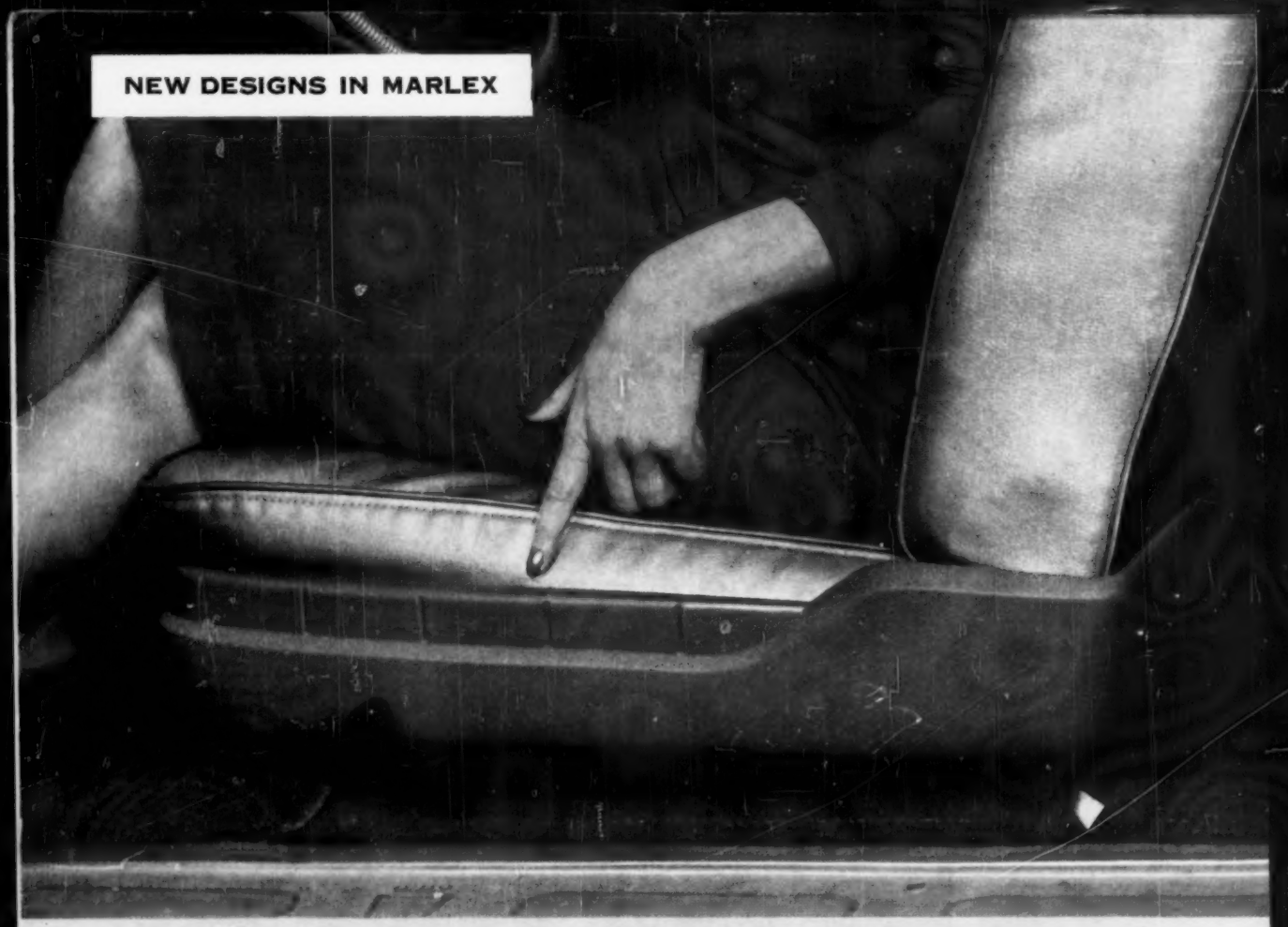

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